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BAIR DAM

MANUAL FOR OPERATION AND MAINTENANCE

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**State Water Projects Bureau
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P.O. Box 201601
Helena, MT 59620-1601**

**Initial Publication May 1995
Revised July 2001**

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OVERVIEW

Bair Dam is located in Meagher County approximately three-quarters of a mile northwest of the town of Checkerboard (Figure 1). The reservoir (and dam) is located on and fed by the North Fork Musselshell River (Figure 2). Figure 3 provides a general layout of the dam, spillway and outlet works. Figure 4 shows the location of the monitoring wells and weir.

The dam is owned by the Montana Department of Natural Resources and Conservation (DNRC) and is managed by the State Water Projects Bureau (SWPB) of the DNRC. The Upper Musselshell Water Users Association (herein called the “association”) operates and maintains the dam.

The earthfill dam was completed in 1939. Bair Dam is 102 feet high and 580 feet long. The dam’s outlet works consists of: a concrete intake structure; a 54-inch reinforced concrete arch conduit; a 48-inch diameter butterfly (operating gate) valve; a 48-inch diameter slide (emergency gate) gate; a control tower; and an outlet structure. The control tower contains the gate operators for the outlet gates. The maximum capacity of the outlet works is 650 cubic feet per second (cfs). The spillway located in the left abutment, is an uncontrolled, rectangular, concrete chute. The spillway has an ogee-shaped crest section at elevation 5,325. The crest is 60 feet wide and tapers to a 20 feet wide chute at the bottom. The maximum capacity of the spillway is 7,880 cfs.

In October, 2000, a feasibility study to rehabilitate the dam was completed by HKM Engineering, Inc. The preferred alternative for rehabilitation is to replace the existing spillway and excavate the adjacent slope to eliminate the talus which creeps into the spillway. The new spillway would have a capacity of 14, 000 cfs with the reservoir pool at the dam crest. HKM is currently working

on the final design and construction is anticipated to begin in the fall of 2001.

Water from the reservoir is primarily used for irrigation water supply. The reservoir is also used for water-based recreation.

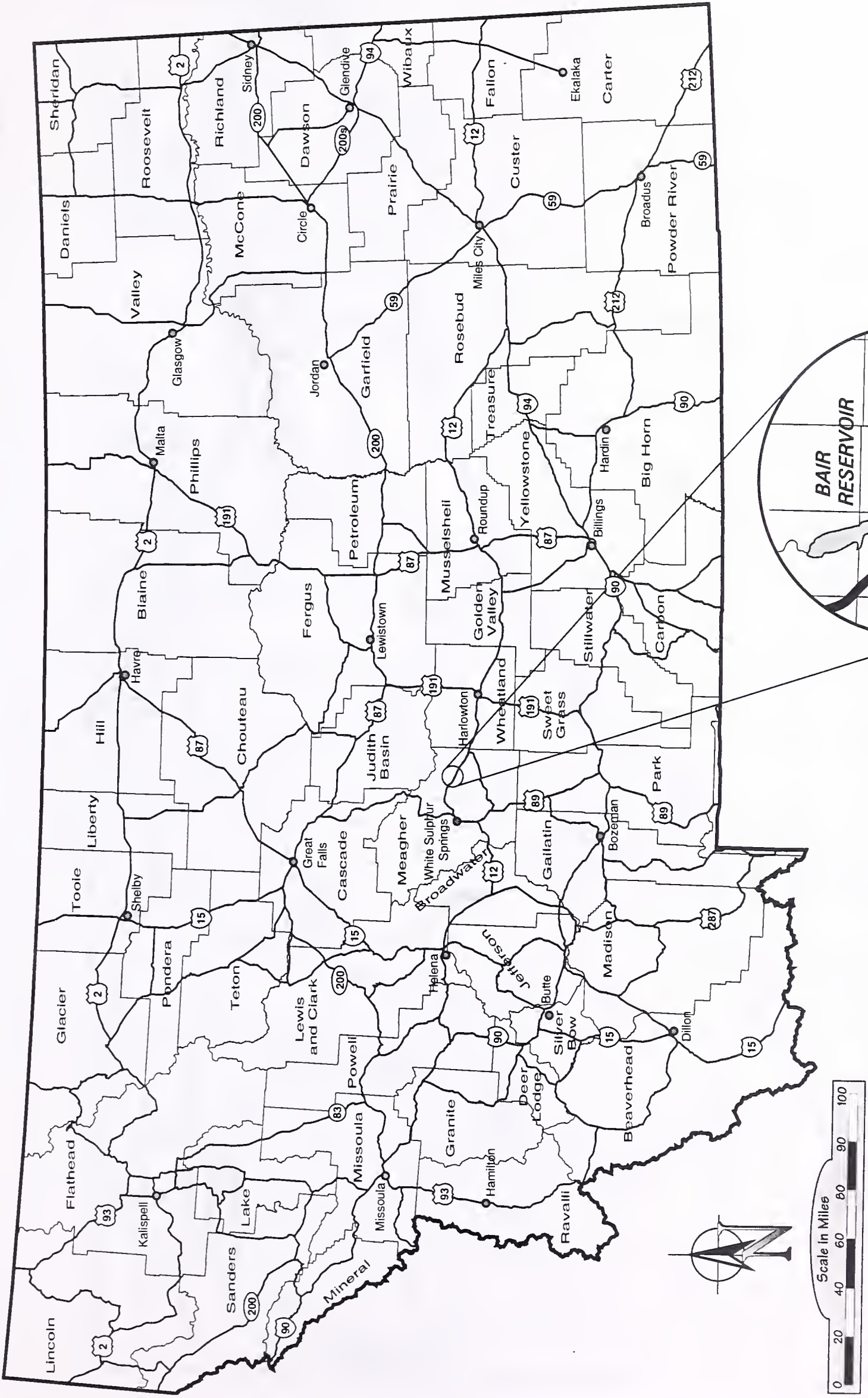


Figure 1. Bair Dam Location Map

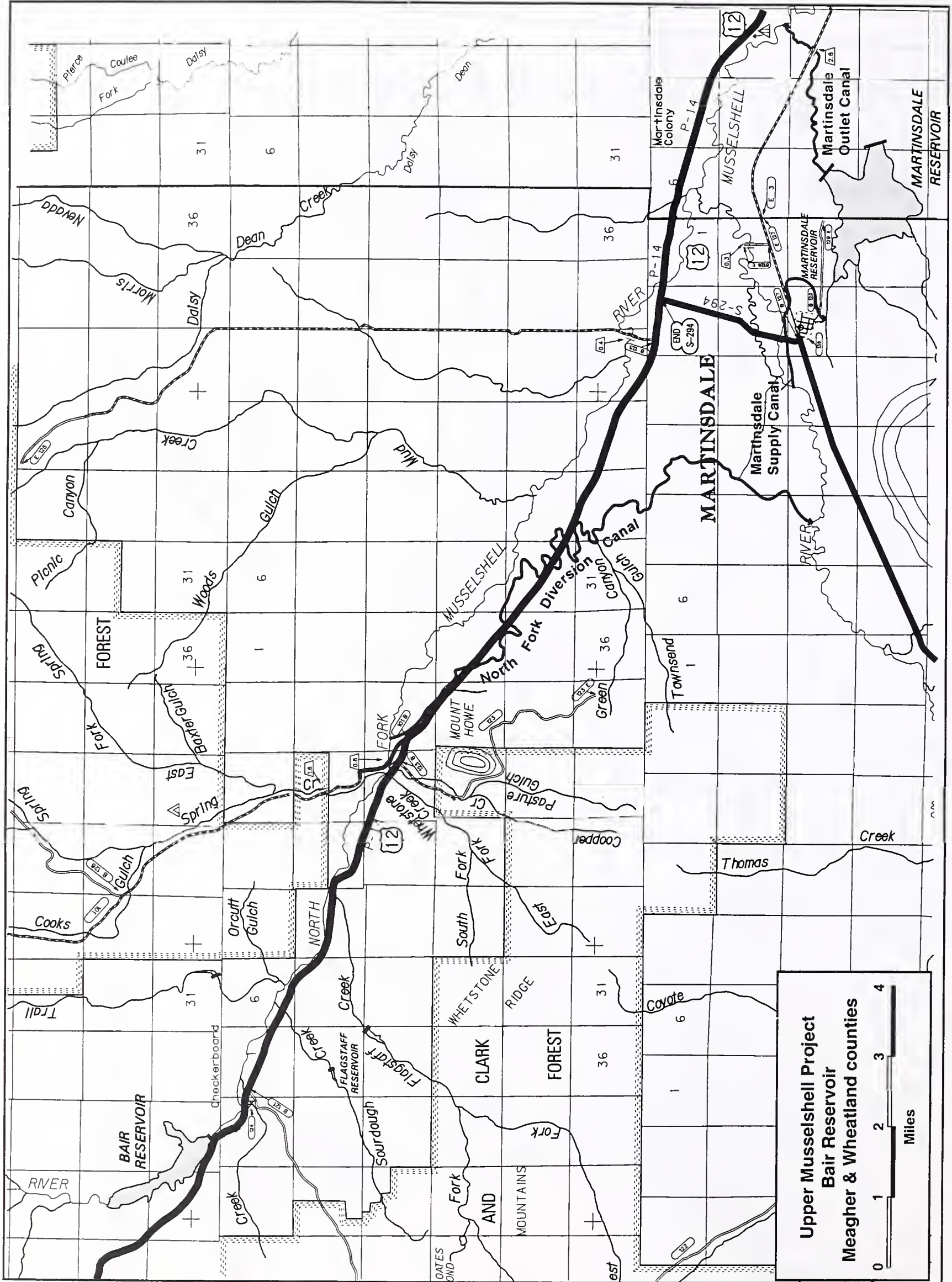


Figure 2. Bair Dam Project Map

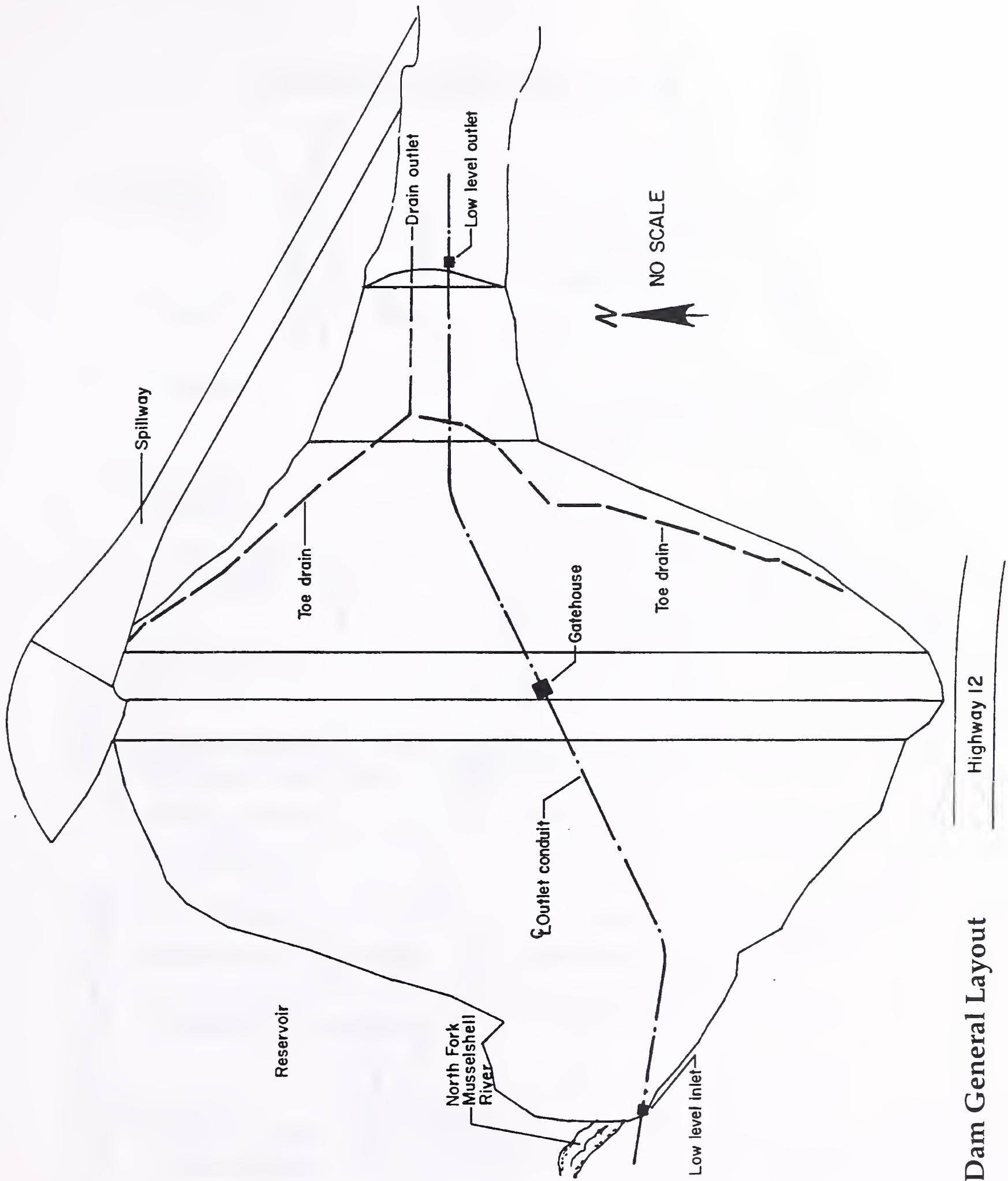


Figure 3. Bair Dam General Layout

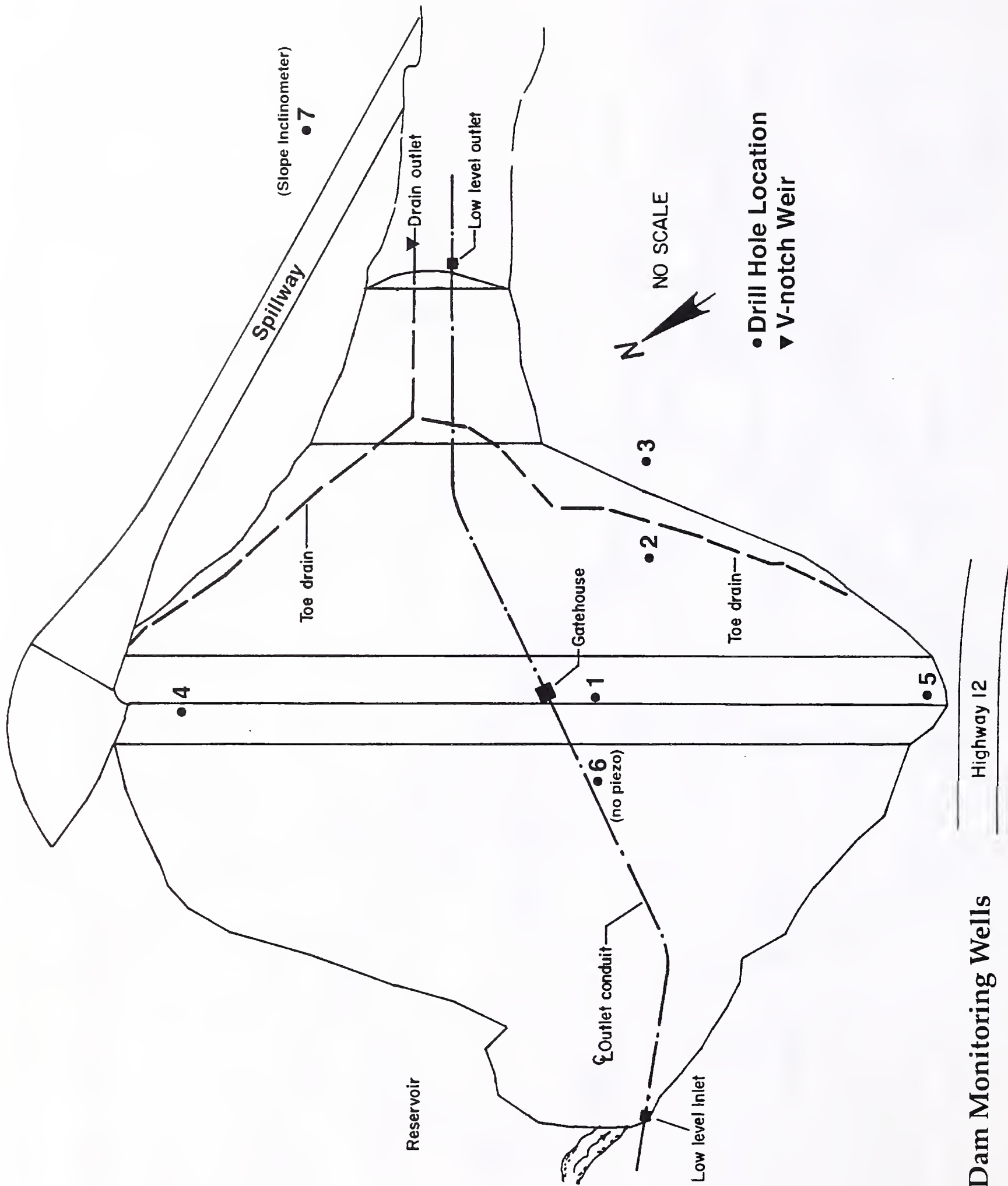


Figure 4. Bair Dam Monitoring Wells Location

STATISTICAL INFORMATION

1. General

- | | |
|-----------------------|--|
| a. Owner | Montana Department of
Natural Resources and
Conservation |
| b. Operator | Upper Musselshell Water
Users Association |
| c. Location | Sections 27, 34 and 35
Township 10 North, Range 9
East MPM |
| d. Latitude | 46.58° |
| Longitude | 110.56° |
| e. County-State | Meagher-Montana |
| f. Watershed Location | North Fork Musselshell River,
Missouri River Basin |
| g. Drainage Area | 51.1 square miles |

2. Principal elevations (feet above mean sea level)

- | | |
|--|---------------|
| a. Minimum Dam Crest | 5,335.78 feet |
| b. Normal Full Pool | 5,324.63 feet |
| c. Spillway Crest | 5,324.63 feet |
| d. Top of Intake | 5,258.36 feet |
| e. Intake Invert (surveyed) | 5,247.36 feet |
| f. Conduit Invert
(inside intake structure) | 5,236.21 feet |

3. Reservoir

- | | |
|--|-----------------------------|
| a. Length of Pool
(approximate) | 1.9 miles |
| b. Maximum Reservoir
Level of Record | 5,325.5 feet (May 16, 1979) |
| c. Surface Area
(at normal full pool) | 272 acres |

4. Storage

- | | |
|--|------------------|
| a. Maximum Storage
(at dam crest) | 10,816 acre-feet |
| b. Active Storage
(at spillway crest) | 7,197 acre feet |
| c. Maximum Surcharge
(from spillway to dam crest) | 3,619 acre-feet |

5. Hydrology

- | | |
|--|------------------------|
| a. Inflow Design Flood
(Probable Maximum Flood) | 22,608 cfs peak inflow |
| b. Dam Safety Rules Flood | 8,207 cfs peak inflow |
| c. 100-Year Flood | 495 cfs |
| d. 500-Year Flood | 1,322 cfs |

6. Embankment (Dam)

- | | |
|--|------------------------------|
| a. Type | Zoned Earthfill and Rockfill |
| b. Hydraulic Height | 102 feet |
| c. Crest Length | 580 feet |
| d. Crest Width | 27 feet |
| e. Downstream Slope
(above elevation 5,270 feet) | 1v on 3.0h |
| f. Downstream Slope
(from elevation 5,250
to 5,270 feet) | 1v on 5.0h |
| g. Downstream Slope
(below elevation 5,250 feet) | 1v on 1.0h |
| h. Upstream Slope
(above elevation 5,325 feet) | 1v on 2.0h |
| i. Upstream Slope
(below elevation 5,325 feet) | 1v on 3.0h |

7. Spillway

- | | |
|--|-----------------------------|
| a. Location | Left abutment |
| b. Type | Uncontrolled Ogee |
| c. Width | 60 feet tapering to 20 feet |
| d. Length | 345 feet |
| e. Maximum Capacity
(pool at dam crest) | 7,880 cfs |

8. Outlet Works

- | | |
|------------------------------------|---|
| a. Size | 54-inch reinforced concrete arch pipe |
| b. Length | 530 feet |
| c. Control | 48-inch diameter butterfly valve (operating gate) and a 48-inch diameter slidegate (emergency gate) with manual operators |
| d. Capacity
(pool at dam crest) | 650 cfs |
| e. Trashrack | Yes |

OPERATING PROCEDURES

The association operates Bair Reservoir to provide an adequate supply of irrigation water to meet contracts with water users without exceeding safe storage or flow levels.

METHOD AND SCHEDULE OF OPERATION

The association's goal is to have the reservoir full before contract holders start putting in calls for water. The date irrigation releases begin varies from year to year, with May 1 typically the earliest. Irrigation releases usually end by September 30 as specified in the water purchase contracts. The actual irrigation season depends on each year's climatological and hydrological conditions.

Reservoir Level Restriction. Because of the poor condition of the spillway at Bair Dam, a reservoir level restriction was implemented in the spring of 1997. This restriction is permanent until the spillway can be repaired. The maximum water surface in the reservoir is to be no more than elevation 5,322.0 feet, which is 2.63 feet below the spillway crest elevation of 5,324.63 feet. The storage at this restricted elevation is 6,500 acre-feet or 697 acre-feet less storage than full pool storage. The restricted storage allows for the routing of the 100-year flood event without putting water through the spillway. Following spillway repairs and determination that the repaired spillway can safely route the spillway design flood as determined by the Dam Safety program, the restriction will be removed.

Maximum Winter Storage: The maximum reservoir elevation for winter storage is 5,315 feet with 4,913 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice.

Minimum Winter Storage: The minimum reservoir elevation for winter storage is 5,275 feet with 687 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works.

Minimum Outlet Discharge: Fish, Wildlife and Parks (FW&P) recommends a minimum flow of 10 to 16 cfs be maintained at the dam outlet to help maintain the fishery in the Musselshell River.

SAFE DRAWDOWN

A geotechnical investigation and analysis of the Bair Dam were completed by HKM Engineering Inc. and the results were published in an October 1, 2000 geotechnical investigation report. The stability of Bair Dam has been thoroughly investigated showing that the rapid drawdown of the upstream face of the dam embankment will not cause a stability problem during rapid drawdown conditions. The drawdown factors indicate that the dam embankment face will remain stable by a considerable amount.

LIMITATION OF APPURTENANCES

Appurtenances at Bair Reservoir include the spillway and outlet works. With the reservoir pool at the dam crest, the maximum capacity of the outlet works is 650 cfs and the maximum spillway capacity is about 7,880 cfs. Flows greater than 7,000 cfs could overtop the spillway sidewalls. Outlet and spillway rating tables are shown in Appendix A.

The maximum gate opening for the low level outlet gate is 2 feet. Openings in excess of this amount may damage the gate, gate frame, gate stem or the gate pedestal. The 2 feet of operation is measured on the exposed portion of the gate stem between the top of the pedestal and the bottom of the stop nut.

DAM OPERATOR

The responsibility for the daily operation of the dam and reservoir rests with the association and its dam operator. The dam operator is generally authorized to operate the reservoir to meet the association's goal of providing an adequate supply of contracted irrigation water without exceeding safe storage or flow levels. The dam operator's specific responsibilities are to:

1. Operate the mechanical features of the outlet works.
2. Coordinate filling of the reservoir and the release of water.
3. Notify the SWPB of unusual occurrences, such as impending floods or excessive seepage.
4. Perform various maintenance tasks.
5. Monitor weather conditions.
6. Monitor seepage.

Typically, the out-going dam operator, water users association, and the SWPB train a new dam operator. The dam operator's training focuses on the mechanical operation of the gates, measurement of the storage level, measurement of the rate of water release, and record keeping. The outlet gates are manually operated with a hand crank. The outlet works are intended to be used for controlling the release of irrigation water and not for providing emergency relief.

The dam operator normally is available to observe the dam and perform operating functions daily during the irrigation season. During the non-irrigation season, one of the officers or directors observe and regulate the dam on a monthly basis. Communication

among the dam operator, the association, and the SWPB usually takes place by telephone. Although not routinely available, radio communication may be established during emergencies or unusual occurrences, so the dam operator can speak directly with county authorities and communicate indirectly with the SWPB (see Bair Dam Emergency Plan).

STORAGE DETERMINATION

Storage volume of the reservoir and elevation of the reservoir surface are determined by taking a slope measurement. There are two locations where slope distance can be measured. The first location is on the upstream side of the dam crest approximately 100 feet north of the gatehouse. The second location is on the south side of the reservoir approximately 900 feet east of the picnic shelter by the boat ramp.

For either location, measure in feet from the 0+00 pin to the water surface. The elevation of the reservoir surface and the storage can then be found using the Slope Distance-Elevation-Storage Tables in Appendix A.

WEATHER MONITORING

The dam operator monitors weather conditions through local weather forecasts and the National Weather Service.

If severe flooding is anticipated, the NWS Great Falls Office (**406-453-2081 or 406-453-4561**) should be contacted for information about the storm, such as the estimated storm intensity and duration, runoff duration (above base flow), and total flood volume of the storm in the Musselshell River drainage.

INTERACTION WITH OTHER DAMS

With the exception of the Fort Peck Dam, the only dams located downstream from Bair Dam are irrigation diversion dams. The safety of these dams are not affected by the operation of Bair Reservoir during either normal or emergency operations. There are no reservoirs of a large size upstream of Bair Dam. Therefore, interaction with other dams is not a concern during the normal operation of Bair Dam.

EMERGENCY

If it appears that the Bair Dam is about to breach, or during emergency operations, the dam operator will initiate the **Bair Dam Emergency Action Plan**.

INSPECTION AND MONITORING

The SWPB will inspect the dam annually. Appendix B includes an example of a SWPB inspection report form. In addition to annual inspections, SWPB personnel will inspect the dam and reservoir during and after heavy runoff and severe rainstorms and windstorms, during high storage periods, and after an earthquake. The water surface through the embankment is monitored by using monitoring wells.

STRUCTURAL FEATURES INSPECTION

Structural features include the control tower, spillway, and outlet works. (Figure 3) The SWPB will inspect these structures annually as part of its inspection program. Items to be checked or noted include, but are not limited to:

1. Outlet Works
 - a. Any differential settlement or movement resulting in cracking of the conduit
 - b. Erosion of the seals or concrete by cavitation immediately downstream of the gates
 - c. Major seepage of water into the conduit
 - d. Major deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions
 - e. Operation of all gates through a full cycle
 - f. Jet pump, for obstructions and operation
 - g. Free, unobstructed operation of the air vent
 - h. Corrosion of any metal
 - i. Proper lubrication of the gate pedestals
2. Gatehouse—Any damage or vandalism
3. Spillway
 - a. Deterioration of concrete
 - b. Separation or movement of joints

- c. Erosion of the spillway chute, backfill behind the walls, or stilling basin
- d. Blockage of the approach or exit channel
- 4. Embankment
 - a. Erosion gullies in the dam
 - b. Damage from burrowing animals or vegetation
 - c. Displacement or loss of rip-rap protection
 - d. Displacement of fill, sink holes, slumps etc.
 - e. Any seepage

RIPRAP INSPECTION

The riprap on the upstream face of the dam should be at least 30 inches thick. Immediately after the occurrence of high water, the riprap will be inspected and additional riprap added if needed.

DRAINS

The drawings for the dam (circa 1938) show a toe drain that begins in each abutment and is joined at the toe and exits to the left of the outlet. The drain outlet cannot be observed since the area where the drain exit is supposed to be located is covered with several feet of loose rock. A backhoe was used in an attempt to locate the toe drainpipe in 1995, but the pipe was not found. However, water does exit from this area into the outlet channel. A V-notch weir was installed in 1997 so the discharge can be measured. See V-notch weir discharge table in Appendix A.

There is also a drainage system beneath the concrete spillway, with two outlet locations in the lower portion of the spillway chute. There are also weep holes in the spillway floor and along the walls of the spillway, but there is no record of the weep holes flowing any water.

MONITORING WELLS

Five drill holes in the dam embankment and one slope inclinometer in the left abutment above the spillway were installed in 1999 (see Figure 4). Generally, two piezometers were installed in each drill hole. Soil profiles of the drill holes and details as to how the wells were constructed are shown in Appendix D.

SEEPAGE MONITORING

Seepage has been observed exiting from around the right outlet tunnel wing wall at irregular intervals. This seepage is not measurable.

The monitoring wells, seepage areas, and drains at the dam are observed and monitored by the dam operator, DNRC Lewistown Regional Office, and SWPB during regular visits; and may be measured by the SWPB during annual inspections. The instruments are generally measured twice per month from May 1 to August 31, and once per month in March, April, September, and October. Measurements may be taken during the winter months (November, December, January, February) depending on weather conditions. The monitoring data is maintained by the SWPB in Helena.

The drill hole for the slope inclinometer is measured with the slope inclinometer four times per year (every three months). Over time the frequency of measurement for the slope inclinometer drill hole may decrease.

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MAINTENANCE

The association is responsible for routine maintenance of the project. In addition, the SWPB may identify items that need maintenance or repair during the annual inspection.

ROUTINE MAINTENANCE

To protect the dam and keep it in good working order, the dam operator during regular visits to the dam will watch for and identify any potential maintenance requirements. As soon as a need is identified, the dam operator needs to schedule and perform the routine maintenance.

Items that may occasionally need attention include, but are not limited to:

1. *Lubrication and cleaning of the gate-operating mechanisms.*
2. *Debris or silt restricting the spillway inlet or the outlet works.* Accumulated debris that could affect the operation of these appurtenances will be removed at once, with all debris removed at least annually before the runoff season.
3. *Erosion gullies on embankment.* Development of erosion gullies will be checked immediately. Gullies will be filled, compacted, and seeded. Particular attention will be paid to the abutment contact areas and the downstream face.
4. *Rodent damage.* The rodents will be removed or destroyed, and any burrow holes should be filled immediately.
5. *Upstream slope riprap.* The upstream face riprap normally will be observed annually, but may occasionally need repairs because of high water or wave action.
6. *Vegetative cover on downstream slopes.* Good vegetative cover will be maintained, but large brush and any trees will be removed.
7. *Noxious weeds.* Noxious weeds on and around the dam embankment and around the reservoir shall be sprayed at least on an annual basis.

8. *Cleaning spillway and outlet wall tops.* Spillway and outlet wall tops should be clear of any dirt, rocks, grass, brush, and any overhanging vegetation or trees.
9. *Repair of the spillway joints and sealing of cracks in the spillway.*
10. *Weir.* This device will be maintained clean of sediment and algae, kept upright, free flowing and free of debris.

ANNUAL MAINTENANCE

The SWPB conducts annual inspections of the Bair Dam and Reservoir. During these inspections, any items requiring annual maintenance will be identified and recorded. Items that may need annual maintenance include the spillway, outlet works, gates, riprap, roads and gatehouse. Other routine items needing immediate attention, such as the need to remove trees or brush, will also be noted.

After the inspection, the SWPB sends the association a Dam Safety Inspection Report and a Maintenance Report. The reports identify items that need maintenance and provide a schedule of when the maintenance tasks need to be completed. The association is responsible for performing the maintenance items within the times specified.

The dam operator or association members may perform the maintenance tasks. However, major repairs will likely to be handled by a contractor. The SWPB may assist in contracting for repairs and may supervise the repair work.

RECORD KEEPING

The SWPB will maintain records, including photographs, of all inspections and maintenance requirements. These records will also include flow measurements and storage volumes. Anyone who

wants to review these records may do so in the SWPB's office at the Department of Natural Resources and Conservation in Helena.

The dam operator will keep records of the reservoir elevation, seepage observation or measurements, and any unusual conditions. These records may be reviewed at the dam operator's house.

REFERENCES

- U.S. Army Corps of Engineers. March 1981. Phase I Inspection Report; National Dam Safety Program; Missouri-Musselshell Basin, Bair Dam and Reservoir, Meagher County, (MT 6). Prepared for the State of Montana (DNRC) by Hoskins-Western-Sonderegger, Inc. under the U.S. Army Corps of Engineers' National Dam Safety Program.
- Berg, Donald, Upper Musselshell Water Users Association President; July 13, 1994.
- Telephone communications with Sterling Sundheim, Regional Office Civil Engineering Specialist, Water Resources Division, DNRC, Lewistown.
- Parish, Lovell, Regional Geologist. 1998. Geotechnical Inspection of Bair Dam - Meagher County, Montana. Prepared for the State of Montana (DNRC) by the Bureau of Reclamation, Great Plains Office, Billings Regional Office, Montana.
- HKM Engineering Inc. October 1, 2000. Bair Dam Rehabilitation Feasibility Study Report. Prepared for the Montana Department of Natural Resources and Conservation, State Water Projects Bureau, Helena, Montana by HKM Engineering Inc. Billings, Montana.
- HKM Engineering Inc. October 1, 2000. Bair Dam Rehabilitation Feasibility Study Report -- Appendices B-E.
- HKM Engineering Inc. October 1, 2000. Bair Dam Rehabilitation Feasibility Study Report -- Appendices G -- Geotechnical Investigation and Analysis.
- HKM Engineering Inc. October 1, 2000. Bair Dam Rehabilitation Feasibility Study Report -- Appendices H -- Hydrologic Investigation and Analysis.

APPENDICES

APPENDIX A

RATING CURVES AND TABLES

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE
BAIR RESERVOIR SOUTH SHORE SLOPE

Pins installed September 6, 2000.

Elevations established with a level on September 14, 2000.

The 0+00 pin located 911 feet east of the HKM CP 2, which is near the picnic shelter by the the boat ramp. The line begins just east of a road gap in the shoreline willows and 55 feet downslope of a steel guard post at a boundary pin and 50 feet from an aluminum cap (CP Z) on the same line.

A white fiberglass post marks the 0+00 pin.

There is no 0+50 pin.

Volume from HKM total storage table of 2000.

DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE
0+00 CAP	5325.55	7,455		36	5320.60	6,151
1	5325.32	7,390		37	5320.54	6,137
2	5325.09	7,325		38	5320.48	6,122
3	5324.86	7,261		39	5320.42	6,108
4	5324.63	7,197		40	5320.35	6,091
SPILLWAY	5324.63	7,197		41	5320.29	6,077
5	5324.41	7,137		42	5320.23	6,062
6	5324.22	7,085		43	5320.16	6,045
7	5324.04	7,036		44	5320.10	6,031
8	5323.86	6,987		45	5320.02	6,012
9	5323.68	6,939		46	5319.93	5,990
10	5323.50	6,890		47	5319.84	5,969
11	5323.32	6,842		48	5319.76	5,950
12	5323.14	6,795		49	5319.67	5,929
13	5322.96	6,746		50	5319.59	5,910
14	5322.77	6,698		51	5319.50	5,889
15	5322.59	6,651		52	5319.42	5,870
16	5322.41	6,605		53	5319.33	5,849
17	5322.29	6,576		54	5319.24	5,828
18	5322.18	6,546		55	5319.16	5,810
19	5322.06	6,515		56	5319.07	5,789
20	5321.94	6,484		57	5318.99	5,771
21	5321.82	6,454		58	5318.90	5,750
22	5321.70	6,424		59	5318.82	5,732
23	5321.58	6,393		60	5318.73	5,711
24	5321.47	6,366		61	5318.64	5,690
25	5321.35	6,336		62	5318.56	5,672
26	5321.23	6,306		63	5318.48	5,654
27	5321.17	6,292		64	5318.41	5,638
28	5321.10	6,274		65	5318.33	5,620
29	5321.04	6,259		66	5318.26	5,604
30	5320.98	6,244		67	5318.18	5,587
31	5320.92	6,230		68	5318.11	5,571
32	5320.85	6,212		69	5318.03	5,553
33	5320.79	6,198		70	5317.96	5,537
34	5320.73	6,183		71	5317.88	5,520
35	5320.67	6,168		72	5317.81	5,504
DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)
BAIR RESERVOIR SOUTH SHORE SLOPE

DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE
73	5317.73	5,487		120	5312.40	4,412
74	5317.66	5,471		121	5312.27	4,388
75	5317.58	5,454		122	5312.15	4,366
76	5317.51	5,438		123	5312.02	4,343
77	5317.43	5,421		124	5311.90	4,321
78	5317.36	5,405		125	5311.77	4,297
79	5317.28	5,388		126	5311.65	4,275
80	5317.21	5,373		127	5311.53	4,253
81	5317.13	5,356		128	5311.40	4,230
82	5317.01	5,330		129	5311.28	4,208
83	5316.88	5,302		130	5311.15	4,186
84	5316.75	5,274		131	5311.03	4,164
85	5316.63	5,248		132	5310.90	4,141
86	5316.50	5,221		133	5310.78	4,120
87	5316.37	5,194		134	5310.66	4,099
88	5316.25	5,168		135	5310.53	4,076
89	5316.12	5,139		136	5310.41	4,056
90	5315.99	5,114		137	5310.31	4,038
91	5315.87	5,090		138	5310.21	4,021
92	5315.74	5,062		139	5310.11	4,004
93	5315.61	5,036		140	5310.02	3,988
94	5315.49	5,012		141	5309.92	3,971
95	5315.36	4,985		142	5309.82	3,953
96	5315.23	4,959		143	5309.72	3,936
97	5315.11	4,935		144	5309.63	3,921
98	5314.98	4,909		145	5309.53	3,904
99	5314.85	4,883		146	5309.43	3,888
100	5314.73	4,859		147	5309.33	3,871
1+00 CAP	5314.68	4,849		148	5309.24	3,856
101	5314.61	4,835		149	5309.14	3,839
102	5314.50	4,813		150	5309.04	3,822
103	5314.38	4,790		1+50 CAP	5308.99	3,814
104	5314.26	4,766		151	5308.99	3,814
105	5314.15	4,745		152	5308.93	3,804
106	5314.03	4,722		153	5308.87	3,794
107	5313.91	4,698		154	5308.82	3,786
108	5313.80	4,670		155	5308.76	3,776
109	5313.68	4,654		156	5308.71	3,768
110	5313.57	4,632		157	5308.65	3,758
111	5313.45	4,610		158	5308.59	3,748
112	5313.33	4,587		159	5308.54	3,740
113	5313.22	4,566		160	5308.48	3,730
114	5313.10	4,543		161	5308.42	3,720
115	5312.98	4,520		162	5308.37	3,712
116	5312.87	4,500		163	5308.31	3,703
117	5312.75	4,478		164	5308.25	3,693
118	5312.64	4,457		165	5308.20	3,685
119	5312.52	4,433		166	5308.14	3,675
DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)
BAIR RESERVOIR SOUTH SHORE SLOPE

DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE
167	5308.08	3,665		214	5307.52	3,576
168	5308.03	3,657		215	5307.52	3,576
169	5307.97	3,647		216	5307.52	3,576
170	5307.91	3,638		217	5307.50	3,570
171	5307.85	3,628		218	5307.47	3,568
172	5307.82	3,623		219	5307.44	3,563
173	5307.79	3,618		220	5307.42	3,560
174	5307.76	3,614		221	5307.39	3,555
175	5307.73	3,609		222	5307.36	3,551
176	5307.70	3,604		223	5307.34	3,547
177	5307.67	3,601		224	5307.31	3,543
178	5307.64	3,594		225	5307.28	3,538
179	5307.61	3,590		226	5307.26	3,545
180	5307.58	3,585		227	5307.23	3,538
181	5307.57	3,583		228	5307.16	3,519
182	5307.55	3,581		229	5307.08	3,507
183	5307.54	3,579		230	5307.01	3,496
184	5307.53	3,578		231	5306.94	3,485
185	5307.51	3,575		232	5306.87	3,474
186	5307.50	3,573		233	5306.79	3,462
187	5307.48	3,570		234	5306.72	3,451
188	5307.47	3,568		235	5306.65	3,440
189	5307.46	3,567		236	5306.58	3,429
190	5307.44	3,563		237	5306.50	3,417
191	5307.43	3,562		238	5306.44	3,408
192	5307.43	3,562		239	5306.37	3,398
193	5307.42	3,560		240	5306.30	3,387
194	5307.41	3,559		241	5306.24	3,377
195	5307.40	3,557		242	5306.17	3,367
196	5307.39	3,555		243	5306.10	3,356
197	5307.38	3,554		244	5306.04	3,347
198	5307.37	3,552		245	5305.94	3,332
199	5307.36	3,551		246	5305.83	3,315
200	5307.35	3,549		247	5305.73	3,301
2+00 CAP	5307.35	3,549		248	5305.63	3,286
201	5307.37	3,552		249	5305.53	3,272
202	5307.39	3,555		250	5305.43	3,256
203	5307.41	3,559		2+50 CAP	5305.39	3,251
204	5307.44	3,563		251	5305.34	3,243
205	5307.46	3,567		252	5305.25	3,230
206	5307.48	3,570		253	5305.17	3,219
207	5307.50	3,570		254	5305.08	3,205
208	5307.52	3,576		255	5305.00	3,193
209	5307.52	3,576		256	5304.91	3,180
210	5307.52	3,576		257	5304.80	3,165
211	5307.52	3,576		258	5304.69	3,149
212	5307.52	3,576		259	5304.58	3,133
213	5307.52	3,576		260	5304.47	3,118
DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)
BAIR RESERVOIR SOUTH SHORE SLOPE

DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE
261	5304.36	3,101		308	5296.26	2,132
262	5304.25	3,086		309	5295.90	2,096
263	5304.14	3,071		310	5295.54	2,066
264	5304.03	3,055		311	5295.17	2,024
265	5303.92	3,040		312	5294.81	1,990
266	5303.81	3,024		313	5294.57	1,968
267	5303.72	3,013		314	5294.32	1,943
268	5303.63	3,000		315	5294.07	1,921
269	5303.53	2,986		316	5293.83	1,900
270	5303.44	2,974		317	5293.58	1,870
271	5303.35	2,962		318	5293.28	1,850
272	5303.25	2,948		319	5292.97	1,823
273	5303.16	2,936		320	5292.67	1,797
274	5303.07	2,924		321	5292.37	1,771
275	5302.97	2,911		322	5292.06	1,745
276	5302.86	2,896		323	5291.76	1,720
277	5302.74	2,880		324	5291.49	1,698
278	5302.63	2,866		325	5291.22	1,676
279	5302.51	2,850		326	5290.96	1,655
280	5302.40	2,836		327	5290.34	1,606
281	5302.28	2,820		328	5289.73	1,560
282	5302.16	2,805		329	5289.12	1,514
283	5302.05	2,790		330	5288.94	1,501
284	5301.93	2,775		331	5288.75	1,488
285	5301.82	2,761		332	5288.57	1,474
286	5301.67	2,742		333	5288.04	1,436
287	5301.52	2,723		334	5287.51	1,399
288	5301.37	2,704		335	5287.02	1,364
289	5301.22	2,686		336	5286.52	1,330
290	5301.06	2,666		337	5286.02	1,297
291	5300.91	2,647		338	5285.67	1,274
292	5300.76	2,629		339	5285.31	1,251
293	5300.55	2,604		340	5284.95	1,228
294	5300.35	2,580		341	5284.48	1,198
295	5300.14	2,555		342	5284.01	1,169
296	5299.93	2,531		343	5283.73	1,151
297	5299.72	2,506		344	5283.45	1,134
298	5299.51	2,482		345	5283.18	1,118
299	5299.31	2,459		346	5282.81	1,095
300	5299.10	2,435		347	5282.45	1,074
3+00 CAP	5299.05	2,430		348	5282.09	1,054
301	5298.75	2,396		349	5281.72	1,031
302	5298.40	2,357		3+50 CAP	5281.71	1,030
303	5298.05	2,318		350	5281.36	1,011
304	5297.70	2,281				
305	5297.35	2,244				
306	5296.98	2,205				
307	5296.62	2,168				
DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE

**TABLE 2. SLOPE-ELEVATION-STORAGE TABLE
BAIR RESERVOIR DAM SLOPE**

The 0+00 is on the upstream side of the dam crest about 100 feet north of the gatehouse.

The 0+50 is a block and ring which is recessed into the gravel about 4 inches.

The 1+00 pin with cap, chain and ropes was installed on November 16, 2000. Its elevation was determined by static GPS methods, controlled to the published elevation for HKM control point # 3, and also tied to the published spillway elevation.

Volume based on surveys by HKM in 1999.

DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE
0+00 TOP	5332.38	9,597		36	5319.12	5,801
0+00 BASE	5331.00	9,131		37	5318.92	5,755
1	5330.60	9,000		38	5318.72	5,709
2	5330.20	8,869		39	5318.53	5,665
3	5329.81	8,743		40	5318.33	5,620
4	5329.41	8,615		41	5318.14	5,578
5	5329.02	8,492		42	5317.96	5,537
6	5328.45	8,315		43	5317.77	5,496
7	5327.89	8,143		44	5317.59	5,456
8	5327.33	7,974		45	5317.40	5,414
9	5326.76	7,805		46	5317.19	5,369
10	5326.20	7,642		47	5316.97	5,321
11	5325.79	7,553		48	5316.75	5,274
12	5325.37	7,404		49	5316.53	5,227
13	5324.96	7,289		50	5316.32	5,183
SPILLWAY	5324.63	7,197		51	5316.10	5,135
14	5324.55	7,175		0+50 BLK	5315.98	5,112
15	5324.14	7,060		54	5315.45	5,004
16	5323.84	6,982		55	5315.23	4,959
17	5323.54	6,901		56	5314.99	4,911
18	5323.25	6,825		57	5314.75	4,863
19	5322.95	6,744		58	5314.51	4,815
20	5322.65	6,668		59	5314.27	4,768
21	5322.42	6,608		60	5314.02	4,720
22	5322.18	6,546		61	5313.76	4,665
23	5321.95	6,487		62	5313.49	4,617
24	5321.71	6,427		63	5313.23	4,568
25	5321.48	6,368		64	5312.96	4,516
26	5321.26	6,314		65	5312.70	4,468
27	5321.04	6,259		66	5312.54	4,437
28	5320.82	6,205		67	5312.38	4,408
29	5320.61	6,153		68	5312.22	4,379
30	5320.39	6,101		69	5312.07	4,352
31	5320.17	6,047		70	5311.91	4,323
32	5319.96	5,997				
33	5319.74	5,945				
34	5319.53	5,896				
35	5319.32	5,847				
DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE

TABLE 2. SLOPE-ELEVATION-STORAGE TABLE (continued)
BAIR RESERVOIR DAM SLOPE

DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE
71	5311.65	4,275		116	5297.14	2,222
72	5311.39	4,228		117	5296.78	2,184
73	5311.13	4,182		118	5296.43	2,149
74	5310.87	4,136		119	5296.07	2,113
75	5310.61	4,090		120	5295.71	2,080
76	5310.10	4,002		121	5295.51	2,063
77	5309.59	3,914		122	5295.30	2,039
78	5309.07	3,827		123	5295.09	2,016
79	5308.56	3,743		124	5294.89	1,998
80	5308.05	3,660		125	5294.68	1,978
81	5307.87	3,631		126	5294.36	1,947
82	5307.69	3,603		127	5294.05	1,919
83	5307.51	3,573		128	5293.73	1,888
84	5307.33	3,546		129	5293.41	1,859
85	5307.15	3,518		130	5293.09	1,833
86	5306.96	3,488		131	5292.56	1,787
87	5306.77	3,459		132	5292.03	1,743
88	5306.59	3,431		133	5291.50	1,699
89	5306.40	3,402		134	5290.97	1,656
90	5306.21	3,373		135	5290.44	1,613
91	5305.95	3,334		136	5289.99	1,579
92	5305.68	3,294		137	5289.55	1,547
93	5305.41	3,254		138	5289.10	1,513
94	5305.14	3,214		139	5288.66	1,481
95	5304.87	3,175		140	5288.21	1,448
96	5304.49	3,121		141	5287.78	1,418
97	5304.11	3,067		142	5287.35	1,388
98	5303.74	3,015		143	5286.92	1,357
99	5303.36	2,963		144	5286.49	1,328
1+00 CAP	5302.98	2,912		145	5286.06	1,300
101	5302.58	2,859		146	5285.75	1,279
102	5302.18	2,808		147	5285.45	1,260
103	5301.78	2,756		148	5285.15	1,241
104	5301.38	2,705		149	5284.85	1,222
105	5300.99	2,657		150	5284.54	1,202
106	5300.57	2,606		151	5284.27	1,185
107	5300.15	2,556		146	5285.75	1,279
108	5299.73	2,507		147	5285.45	1,260
109	5299.32	2,460		148	5285.15	1,241
110	5298.90	2,413		149	5284.85	1,222
111	5298.62	2,382		150	5284.54	1,202
112	5298.34	2,350		151	5284.27	1,185
113	5298.06	2,319				
114	5297.78	2,289				
115	5297.50	2,260				
DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE

TABLE 3. TOTAL STORAGE IN ACRE-FEET**BAIR RESERVOIR**

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
5241	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04
5242	0.06	0.08	0.10	0.13	0.16	0.20	0.25	0.30	0.35	0.41
5243	0.5	0.6	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.5
5244	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.3	3.6
5245	3.8	4.1	4.4	4.8	5.1	5.5	5.8	6.2	6.6	7.1
5246	7.5	8.0	8.4	8.9	9.5	10	11	11	12	12
5247	13	14	14	15	16	16	17	18	19	20
5248	20	21	22	23	23	24	25	26	27	28
5249	28	29	30	31	32	33	33	34	35	36
5250	37	38	39	40	41	42	43	44	45	46
5251	47	48	49	50	51	52	53	54	55	56
5252	57	58	59	60	61	63	64	65	66	67
5253	68	69	71	72	73	74	76	77	78	79
5254	81	82	83	85	86	87	89	90	91	93
5255	94	95	97	98	100	101	103	104	106	107
5256	109	110	112	113	115	117	118	120	122	123
5257	125	127	129	130	132	134	136	138	139	141
5258	143	145	147	149	151	153	155	157	159	161
5259	163	165	167	170	172	174	176	178	181	183
5260	185	187	190	192	194	197	199	202	204	206
5261	209	211	214	216	218	221	223	226	228	231
5262	233	236	239	241	244	246	249	252	254	257
5263	259	262	265	267	270	273	276	278	281	284
5264	287	289	292	295	298	301	304	307	309	312
5265	315	318	321	324	327	330	333	336	339	342
5266	345	348	351	355	358	361	364	367	370	374
5267	377	380	383	387	390	393	397	400	403	407
5268	410	414	417	420	424	427	431	434	438	441
5269	445	449	452	456	459	463	467	470	474	478
5270	482	485	489	493	497	501	504	508	512	516
5271	520	524	528	532	535	539	543	547	551	555
5272	559	563	568	572	576	580	584	588	592	596
5273	600	605	609	613	617	622	626	630	634	639
5274	643	647	652	656	661	665	669	674	678	683
5275	687	692	696	701	705	710	714	719	724	728

TABLE 3. TOTAL STORAGE IN ACRE-FEET (continued)**BAIR RESERVOIR**

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
5276	733	738	742	747	752	757	761	766	771	776
5277	781	785	790	795	800	805	810	815	820	825
5278	830	835	840	845	851	856	861	866	871	876
5279	882	887	892	897	903	908	914	919	924	930
5280	935	941	946	952	957	963	968	974	979	985
5281	991	996	1,002	1,008	1,013	1,019	1,025	1,030	1,036	1,042
5282	1,048	1,054	1,059	1,065	1,071	1,077	1,083	1,089	1,095	1,101
5283	1,107	1,113	1,119	1,125	1,131	1,137	1,143	1,149	1,155	1,162
5284	1,168	1,174	1,180	1,187	1,193	1,199	1,205	1,212	1,218	1,224
5285	1,231	1,237	1,244	1,250	1,256	1,263	1,269	1,276	1,283	1,289
5286	1,296	1,302	1,309	1,316	1,322	1,329	1,336	1,343	1,350	1,356
5287	1,363	1,370	1,377	1,384	1,391	1,398	1,405	1,412	1,419	1,426
5288	1,433	1,440	1,447	1,455	1,462	1,469	1,476	1,484	1,491	1,498
5289	1,506	1,513	1,520	1,528	1,535	1,543	1,550	1,558	1,565	1,573
5290	1,580	1,588	1,596	1,603	1,611	1,619	1,627	1,635	1,643	1,650
5291	1,658	1,666	1,674	1,683	1,691	1,699	1,707	1,715	1,724	1,732
5292	1,740	1,749	1,757	1,765	1,774	1,782	1,791	1,800	1,808	1,817
5293	1,826	1,834	1,843	1,852	1,861	1,870	1,879	1,888	1,897	1,906
5294	1,915	1,924	1,933	1,943	1,952	1,961	1,971	1,980	1,989	1,999
5295	2,008	2,018	2,027	2,037	2,047	2,057	2,066	2,076	2,086	2,096
5296	2,106	2,116	2,126	2,136	2,146	2,156	2,166	2,176	2,187	2,197
5297	2,207	2,218	2,228	2,239	2,249	2,260	2,270	2,281	2,292	2,303
5298	2,313	2,324	2,335	2,346	2,357	2,368	2,379	2,390	2,401	2,413
5299	2,424	2,435	2,446	2,458	2,469	2,481	2,492	2,504	2,515	2,527
5300	2,539	2,550	2,562	2,574	2,586	2,598	2,610	2,622	2,634	2,646
5301	2,659	2,671	2,683	2,696	2,708	2,721	2,733	2,746	2,758	2,771
5302	2,784	2,797	2,810	2,823	2,836	2,849	2,862	2,875	2,888	2,901
5303	2,915	2,928	2,942	2,955	2,969	2,982	2,996	3,010	3,023	3,037
5304	3,051	3,065	3,079	3,093	3,107	3,122	3,136	3,150	3,165	3,179
5305	3,193	3,208	3,223	3,237	3,252	3,267	3,282	3,296	3,311	3,326
5306	3,341	3,356	3,371	3,387	3,402	3,417	3,432	3,448	3,463	3,479
5307	3,494	3,510	3,525	3,541	3,557	3,573	3,588	3,604	3,620	3,636
5308	3,652	3,668	3,685	3,701	3,717	3,733	3,750	3,766	3,783	3,799
5309	3,816	3,832	3,849	3,866	3,883	3,899	3,916	3,933	3,950	3,967
5310	3,985	4,002	4,019	4,036	4,054	4,071	4,088	4,106	4,124	4,141

TABLE 3. TOTAL STORAGE IN ACRE-FEET (continued)**BAIR RESERVOIR**

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
5311	4,159	4,177	4,194	4,212	4,230	4,248	4,266	4,284	4,302	4,321
5312	4,339	4,357	4,375	4,394	4,412	4,431	4,449	4,468	4,487	4,505
5313	4,524	4,543	4,562	4,581	4,600	4,619	4,638	4,658	4,677	4,696
5314	4,716	4,735	4,755	4,774	4,794	4,813	4,833	4,853	4,873	4,893
5315	4,913	4,933	4,953	4,973	4,993	5,014	5,034	5,054	5,075	5,096
5316	5,116	5,137	5,158	5,179	5,200	5,221	5,242	5,263	5,285	5,306
5317	5,328	5,349	5,371	5,392	5,414	5,436	5,458	5,480	5,502	5,524
5318	5,546	5,569	5,591	5,613	5,636	5,658	5,681	5,704	5,727	5,750
5319	5,773	5,796	5,819	5,842	5,865	5,889	5,912	5,936	5,959	5,983
5320	6,007	6,031	6,055	6,079	6,103	6,127	6,151	6,176	6,200	6,225
5321	6,249	6,274	6,299	6,323	6,348	6,373	6,398	6,424	6,449	6,474
5322	6,500	6,525	6,551	6,576	6,602	6,628	6,654	6,680	6,706	6,732
5323	6,758	6,784	6,811	6,837	6,864	6,890	6,917	6,944	6,971	6,998
5324	7,025	7,052	7,079	7,107	7,134	7,161	7,189	7,217	7,244	7,272
5325	7,300	7,328	7,356	7,384	7,413	7,441	7,469	7,498	7,526	7,555
5326	7,584	7,613	7,642	7,671	7,700	7,729	7,758	7,787	7,817	7,846
5327	7,876	7,906	7,935	7,965	7,995	8,025	8,055	8,086	8,116	8,146
5328	8,177	8,207	8,238	8,269	8,299	8,330	8,361	8,392	8,424	8,455
5329	8,486	8,518	8,549	8,581	8,612	8,644	8,676	8,708	8,740	8,772
5330	8,804	8,837	8,869	8,902	8,934	8,967	9,000	9,032	9,065	9,098
5331	9,131	9,165	9,198	9,231	9,265	9,298	9,332	9,365	9,399	9,433
5332	9,467	9,501	9,535	9,569	9,604	9,638	9,673	9,707	9,742	9,777
5333	9,811	9,846	9,881	9,917	9,952	9,987	10,022	10,058	10,093	10,129
5334	10,165	10,201	10,236	10,272	10,309	10,345	10,381	10,417	10,454	10,490
5335	10,527	10,564	10,600	10,637	10,674	10,711	10,749	10,786	10,823	10,861
5336	10,898	10,936	10,974	11,011	11,049	11,087	11,125	11,164	11,202	11,240
5337	11,279	11,317	11,356	11,394	11,433	11,472	11,511	11,550	11,589	11,629
5338	11,668	11,708	11,747	11,787	11,827	11,866	11,906	11,946	11,986	12,027
5339	12,067	12,107	12,148	12,188	12,229	12,270	12,311	12,352	12,393	12,434
5340	12,475	12,517	12,558	12,600	12,641	12,683	12,725	12,767	12,809	12,851
5341	12,893	12,935	12,977	13,020	13,062	13,105	13,148	13,190	13,233	13,276
5342	13,319	13,362	13,406	13,449	13,492	13,536	13,579	13,623	13,667	13,711
5343	13,755	13,799	13,843	13,887	13,931	13,976	14,020	14,065	14,110	14,154
5344	14,199	14,244	14,289	14,335	14,380	14,425	14,471	14,516	14,562	14,607
5345	14,653									

Note: Active storage table based upon surveys by HKM in 1999.

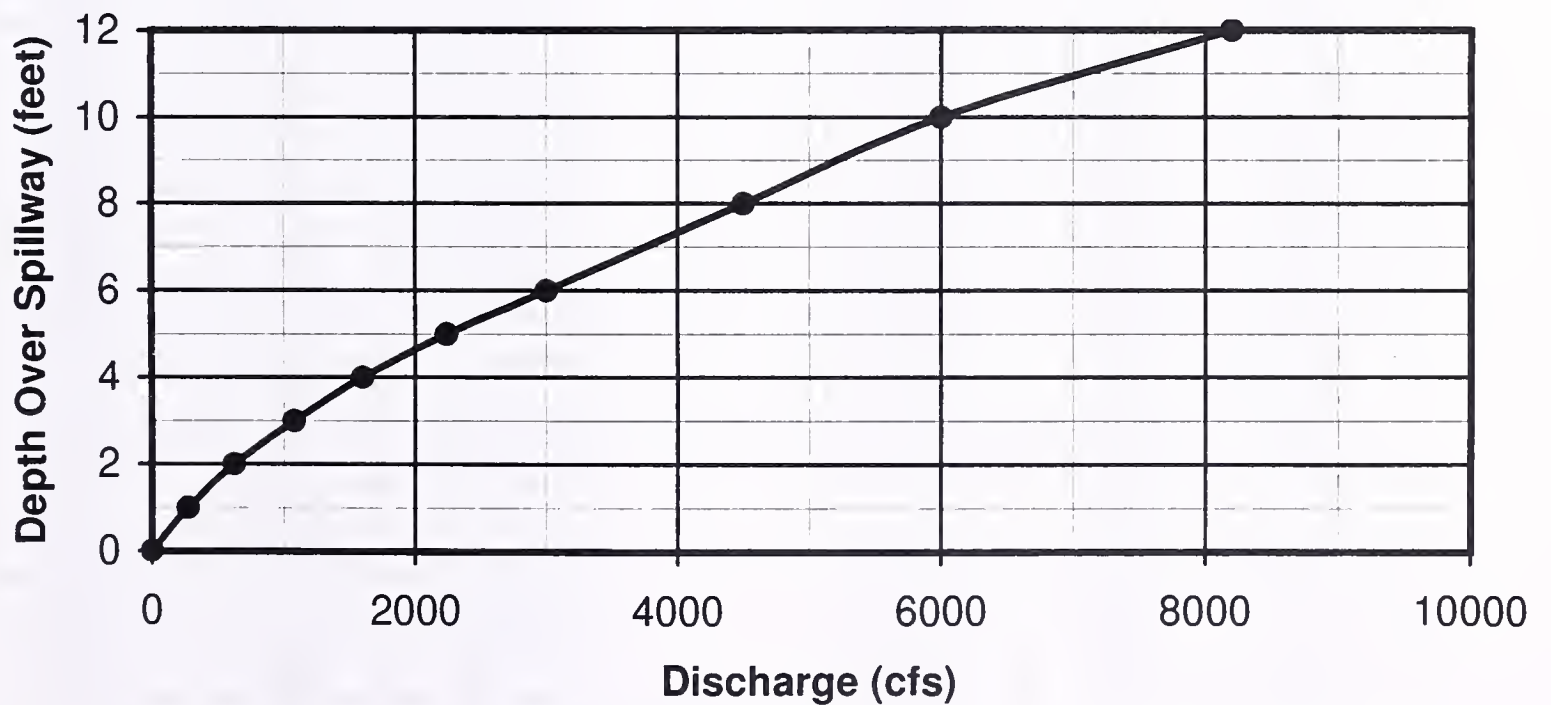
Spillway Crest Elevation 5,324.63 feet Storage 7,197 acre-feet
 Dam Crest Elevation 5,335.78 feet Storage 10,816 acre-feet

TABLE 4. SPILLWAY DISCHARGE

BAIR RESERVOIR

Depth Over Crest (feet)	Elevation (feet)	Discharge (cfs)
0	5324.6	0
1.0	5325.6	275
2.0	5326.6	625
3.0	5327.6	1080
4.0	5328.6	1600
5.0	5329.6	2240
6.0	5330.6	3000
8.0	5332.6	4500
10.0	5334.6	6000
12.0	5336.6	8200

BAIR DAM SPILLWAY RATING CURVE



Note: Data from the Corps of Engineers Phase 1 Inspection Report (1981).

TABLE 5. V-NOTCH WEIR RATING TABLE

HEAD (IN)	DISCHARGE			HEAD (IN)	DISCHARGE	
	(GPM)	(CFS)			(GPM)	(CFS)
-----	-----	-----		4.1	77.8	0.173
-----	-----	-----		4.2	82.6	0.184
-----	-----	-----		4.3	87.5	0.195
-----	-----	-----		4.4	92.6	0.206
0.5	0.4	0.001		4.5	98.0	0.218
0.6	0.7	0.001		4.6	103.4	0.230
0.7	1.0	0.002		4.7	109.1	0.243
0.8	1.4	0.003		4.8	115.0	0.256
0.9	1.8	0.004		4.9	121.0	0.270
1.0	2.4	0.005		5.0	127.2	0.283
1.1	3.0	0.007		5.1	133.6	0.298
1.2	3.7	0.008		5.2	140.2	0.312
1.3	4.5	0.010		5.3	147.0	0.328
1.4	5.4	0.012		5.4	154.0	0.343
1.5	6.4	0.014		5.5	161.2	0.359
1.6	7.5	0.017		5.6	168.5	0.375
1.7	8.8	0.020		5.7	176.1	0.392
1.8	10.1	0.022		5.8	183.8	0.410
1.9	11.5	0.026		5.9	191.8	0.427
2.0	13.1	0.029		6.0	199.9	0.445
2.1	14.8	0.033		6.1	208.3	0.464
2.2	16.6	0.037		6.2	216.9	0.483
2.3	18.5	0.041		6.3	225.6	0.503
2.4	20.6	0.046		6.4	234.6	0.523
2.5	22.8	0.051		6.5	243.8	0.543
2.6	25.1	0.056		6.6	253.2	0.564
2.7	27.6	0.061		6.7	262.9	0.586
2.8	30.2	0.067		6.8	272.7	0.608
2.9	32.9	0.073		6.9	282.8	0.630
3.0	35.8	0.080		7.0	293.0	0.653
3.1	38.9	0.087		7.1	303.5	0.676
3.2	42.1	0.094		7.2	314.2	0.700
3.3	45.4	0.101		7.3	325.2	0.725
3.4	48.9	0.109		7.4	336.3	0.749
3.5	52.5	0.117		7.5	347.7	0.775
3.6	56.3	0.126		7.6	359.3	0.801
3.7	60.3	0.134		7.7	371.2	0.827
3.8	64.4	0.144		7.8	383.2	0.854
3.9	68.7	0.153		7.9	395.5	0.881
4.0	73.1	0.163		8.0	408.1	0.909

$$Q = (2.49 (H/12)^{2.48})(448.83)$$

Q in gpm

H in inches

APPENDIX B
INSPECTION REPORT FORM

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
DAM SAFETY INSPECTION REPORT

NAME OF DAM _____
DATE INSPECTED _____

INVENTORY NO. _____
HAZARD CATEGORY _____
TYPE OF DAM _____
YEAR BUILT _____

OWNER _____
OPERATOR _____
STREAM _____
DRAINAGE AREA _____

Reservoir Storage Status

	Water Surface Elevation (feet)	Storage (acre-feet)
At time of inspection	_____	_____
At spillway crest	_____	_____
At min. dam crest elevation	_____	_____

ITEM	YES	NO	REMARKS
------	-----	----	---------

1. EMBANKMENT

A. Crest -- Height= Length= Width=

(1) Any visual settlements?			
(2) Any misalignments?			
(3) Any cracking?			
(4) Any traffic damage?			
(5) Other?			

ITEM	YES	NO	REMARKS
------	-----	----	---------

1. EMBANKMENT (continued)

B. Upstream Face -- Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Is riprap protection adequate?			
(5) Any stone deterioration?			
(6) Any visual settlement, slumps, sloughing, depressions or bulges?			
(7) Adequate grass cover?			
(8) Debris on the dam face?			
(9) Other?			

C. Downstream Face--Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Any visual settlement, slumps, sloughing, depressions or bulges?			
(5) Is the toe drain dry?			
(6) Are the relief wells flowing?			
(7) Any boils at the toe?			
(8) Any seepage areas?			
(9) Any traffic or animal damage?			
(10) Any burrowing animals?			
(11) Adequate grass cover?			
(12) Other?			

D. Amount and Type of Vegetation on the Dam

--

ITEM	YES	NO	REMARKS
------	-----	----	---------

2. ABUTMENT CONTACTS

A) Any erosion?			
B) Any visual differential movement?			
C) Any cracks?			
D) Any seepage present?			
E) Other?			

3. OUTLET WORKS

A. Intake Structure -- Size=

(1) Any settlement?			
(2) Any tilting?			
(3) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(4) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(5) Metal appurtenances:			
a. Any corrosion present?			
b. Any breakage present?			
(6) Trash rack?			
a. Condition?			
b. Anchor system secure?			
(7) Other?			

ITEM	YES	NO	REMARKS
------	-----	----	---------

3. OUTLET WORKS (continued)

B. Conduit -- Type = Size =

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Is the conduit metal?			
a. Any corrosion present?			
b. Protective coatings adequate?			
(4) Is the conduit misaligned?			
(5) Any calcium deposits?			
(6) Other?			

C. Gates and Tower

(1) Gates:			
a. Size: Operating:		Emergency:	
b. Type: Operating:		Emergency:	
(2) Controls operational?			
(3) Controls lubricated?			
(4) Operational problems?			
(5) Leakage around gates?			
(6) Condition of gate seals?			
(7) Any cavitation damage? If so, describe?			
(8) Describe air vent-size and condition.			

ITEM	YES	NO	REMARKS
------	-----	----	---------

3. OUTLET WORKS (continued)

C. Gates and Tower (continued)

(9) Is there a jet pump?			
a. Is it operational?			
b. Leakage?			
(10) Is the tower dry? ____ wet? ____			
(11) Any seepage in the tower?			
(12) Condition of the tower?			
(13) Any safety problems?			
(14) Ladder in good condition?			
(15) Condition of the gatehouse?			
(16) Emergency plan completed for the dam?			
a. Posted in the gatehouse?			
(17) Other?			

D. Stilling Basin

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Do energy dissipaters show:			
a. Signs of deterioration?			
b. Are they covered with debris?			
(4) Other?			

ITEM	YES	NO	REMARKS
------	-----	----	---------

3. OUTLET WORKS (continued)

E. Downstream Channel

(1) Is the channel:			
a. Eroding or backcutting?			
b. Sloughing?			
c. Obstructed?			
(2) Is released water:			
a. Undercutting the outlet?			
b. Eroding the embankment?			
(3) Other?			

4. SPILLWAY

A. Description

(1) Location?			
(2) Type of Spillway?			
(3) Size of Spillway?			
(4) Spillway lining?			
(5) Is there a weir?			
(6) Is the spillway in good condition?			
(7) Any drains?			
a. Describe the condition of drains.			

B. Does spillway show:

(1) Any cracking concrete?			
(2) Any spalling concrete?			
(3) Any exposed reinforcement in the concrete?			
(4) Any erosion?			

ITEM	YES	NO	REMARKS
------	-----	----	---------

4. SPILLWAY (continued)

4. B. Does spillway show: (continued)

(5) Any slope sloughing?			
(6) Any obstructions?			
(7) Displacement or offset joints?			
(8) Loss of joint material?			
(9) Leakage at the joints?			
(10) Other?			

C. Do the energy dissipaters show:

(1) Signs of deterioration?			
(2) Any cracking?			
(3) Any spalling?			
(4) Any exposed reinforcement?			
(5) Are they covered with debris?			
(6) Other?			

D. Has release water:

(1) Eroded the embankment?			
(2) Undercut the outlet?			
(3) Eroded the downstream channel?			
(4) Other?			

E. Emergency Spillway

(1) Is there an emergency spillway?			(If YES, describe)

ITEM	YES	NO	REMARKS
------	-----	----	---------

5. RESERVOIR CONTROL

A) Recent upstream development?			
B) Recent downstream development?			
C) Slides in reservoir area?			
D) Change in reservoir operation?			
E) Large impoundment upstream?			
F) Any debris in the reservoir?			
G) Other?			

6. INSTRUMENTATION

A) List type(s) of instrumentation:			
B) In good condition?			
C) Read periodically?			
D) Is data available?			
E) Include all data gathered since last report.			

7. DOWNSTREAM CONDITION

A. Downstream Land Use.

This dam was inspected by:

Additional comments and recommendations.

APPENDIX C
DISTRIBUTION LIST

BAIR O&M DISTRIBUTION LIST

	<u>Number Of Copies</u>
1. State Water Projects Bureau Glen McDonald Greg Ames (vacant) Art Taylor (2) Bob Arrington Bob Clark Delores Eustice	7
2. DNRC Information Services Section	1
3. DNRC Lewistown Regional Office Scott Irwin Sterling Sundheim	2
4. DNRC Dam Safety	1
5. Water Users Eugene Taber -- President Kenneth Yerger -- Vice President Susan Moore -- Secretary/Treasurer	3
6. Dam Operator Dam Operator (Keith Hill) Gate House	2
7. State Library -- Attn: Roberta Gebhardt	4
8. Extra	2
=====	
TOTAL	22

APPENDIX D

MONITORING WELL LOGS

GEOTECHNICAL DRILLING PROGRAM RATIONALE

DRILL HOLE NO.	LOCATION	ANTICIPATED (ACTUAL) DEPTH (ft)	PIEZOMETER COMPLETION	PURPOSE(S)
99-1	Dam crest @ maximum section	120 (128.4)	(1) Embankment observation well	Determine embankment and foundation material properties, nature of foundation contact and phreatic surface location at maximum section for slope stability analysis.
99-2	Downstream face at two-thirds the dam height above the toe	90 (67.0)	(1) Embankment observation well	(see above)
99-3	Downstream toe near 2:1/5:1 slope break	60 (52.5)	(1) Foundation open-system piezometer	(see above)
99-4	Left dam crest near spillway inlet	40 (51.0)	(1) Abutment open-system piezometer	Determine seepage and geologic conditions in the left abutment, determine the nature of the foundation contact and cutoff for the spillway and bedrock for excavation potential.
99-5	Right dam abutment	40 (92.6)	(1) Observation well	Determine seepage and geologic conditions in the right abutment.
99-6	Upstream face	85 (62.8)	None	Obtain data from upstream impervious zone; identify cut-off trench material and nature of contact with bedrock.
99-7	Slope above spillway	0 (98.6)	1.9" diameter inclinometer casing	Evaluate materials in slope above spillway and install inclinometer casing.

ROCK CLASSIFICATION DESCRIPTIONS

ROCK STRENGTH

Class	Strength	Field Test	Approximate Range of Uniaxial Compressive Strength kg/cm ² (tons/ft ²)
I	Extremely Strong	Many blows with geologic hammer required to break intact specimen.	>2000
II	Very Strong	Hand held specimen breaks with hammer end of pick under more than one blow.	2000-1000
III	Strong	Cannot be scraped or peeled with knife, hand held specimen can be broken with single moderate blow with pick.	1000-500
IV	Moderately Strong	Can just be scraped or peeled with knife. Indentations 1mm to 3mm show in specimen with moderate blow with pick.	500-125
V	Moderately Weak to Weak	Material crumbles under moderate blow with sharp end of pick and can be peeled with a knife, but is too hard to hand trim for triaxial test specimen.	125-12

WEATHERING

Grade	Symbol	Diagnostic Features
Fresh	F	No visible sign of decomposition or discoloration. Rings when struck by hammer.
Slightly Weathered	WS	Slight discoloration inwards from open fractures, otherwise similar to F.
Moderately Weathered	WM	Discoloration throughout. Weaker minerals such as feldspar decomposed. Strength somewhat less than fresh rock but cores cannot be broken by hand or scraped by knife. Texture preserved.
Highly Weathered	WH	Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with knife. Core stones present in rock mass. Texture becoming indistinct but fabric preserved.
Completely Weathered	WC	Minerals decomposed to soil but fabric and structure preserved (Saprolite). Specimens easily crumbled or penetrated.
Residual Soil	RS	Advanced state of decomposition resulting in plastic soils. Rock fabric and structure completely destroyed. Large volume change.

STRUCTURAL PARAMETERS

Description for Structural Features: Bedding, Foliation, or Flow Banding	Spacing	Description for Joints, Faults or Other Fractures
Very Thickly (bedded, foliated, or banded)	More than 6 feet	Very Widely (fractured or jointed)
Thickly	2 - 6 feet	Widely
Medium	8 - 24 inches	Medium
Thinly	2½ - 8 inches	Closely
Very Thinly	¾ - 2½ inches	Very Closely
Description for Microstructural Features: Lamination, Foliation, or Cleavage		Description for Joints, Faults or Other Fractures
Intensely (laminated, foliated or cleaved)	¼ - ¾ inch	Extremely Close
Very Intensely	Less than ¼ inch	

RQD

RQD (Rock Quality Designation)	Description of Rock Quality
0 - 25%	Very Poor
25 - 50%	Poor
50 - 75%	Fair
75 - 90%	Good
90 - 100%	Very Good

SOIL CLASSIFICATION/LEGEND

Unified Soil Classification System					
Criteria for Assigning Group Symbols and Names			Soil Classification Generalized Group Descriptions		
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS Less than 5% fines	GW	Well-graded gravels	
			GP	Poorly-graded gravels	
	SANDS 50% or more of coarse fraction passes No. 4 sieve	GRAVELS w/ FINES More than 12% fines	GM	Gravel and silt mixtures	
			GC	Gravel & clay mixtures	
		CLEAN SANDS Less than 5% fines	SW	Well-graded sands	
			SP	Poorly-graded sands	
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	SILTS & CLAYS Liquid limit less than 50	INORGANIC	SM	Sand and silt mixtures	
			SC	Sand and clay mixtures	
		ORGANIC	CL	Low-plasticity clays	
			ML	Non-plastic and low-plasticity silts	
	SILTS & CLAYS Liquid limit Greater than 50	INORGANIC	OL	Non-plastic and low-plasticity organic clays	
				Non-plastic and low-plasticity organic silts	
		ORGANIC	CH	High-plasticity clays	
			MH	High-plasticity silts	
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		OH	High-plasticity organic clays	
				High-plasticity organic soils	
			PT	peat	

Component Definitions By Gradation	
Component	Size Range
Boulders	Greater than 12 in.
Cobbles	3 in. to 12 in.
Gravel	3 in. to No. 4 (4.75 mm)
Coarse gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (.075 mm)
Coarse sand	No. 4 (4.75 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.425 mm)
Fine sand	No. 40 (0.425 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

Silt and Clay Descriptions	
Description	Typical Unified Designation
Silt	ML (non-plastic)
Clayey Silt	CL-ML (low plasticity)
Silty Clay, Lean Clay	CL
Clay, Fat Clay	CH
Plastic Silt	MH
Organic Soils	OL, OH, Pt

Relative Density or Consistency Utilizing Standard Penetration Test Values					
Cohesionless Soils ^(a)			Cohesive Soils ^(a)		
Density ^(b)	N blows/ft ^(c)	Relative Density (%)	Consistency	N blows/ft ^(c)	Undrained Shear Strength ^(d) (psf)
Very loose	0 to 4	0 - 15	Very soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	Over 50	>85	Very Stiff	15 to 30	2000 - 4000
			Hard	Over 30	>4000

- (a) Soils consisting of gravel, sand and silt, either separately or in combination, possessing no characteristics of plasticity and exhibiting drained behavior.
- (b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.
- (c) Refer to text of ASTM D 1586 for a definition of N; in normally consolidated cohesionless soils relative density terms are based on N values corrected for overburden pressures.
- (d) Undrained shear strength = ½ unconfined compressive strength.

Groundwater Elevation	
	Water Elevation Noted During Drilling
	Water Elevation Recorded After Drilling Complete
	Water Elevation Recorded After Auger Removal

Soil Moisture	
Dry	Dry of the optimum moisture content.
Moist	Approximately at optimum moisture.
Very Moist To Wet	Wet of optimum to saturated.

Descriptive Terminology Denoting Components Proportions	
Descriptive Terms	Range of Proportion
Trace	0 - 5%
Little	5 - 12%
Some or Adjective ^(a)	12 - 30%
And	30 - 50%

(a) Use gravelly, sandy or silty as appropriate.

Samples	
	Split Spoon Sampler (2.0" OD)
	Ring Sampler (3.0" OD)
	* Indicates increased blow counts due to sampler size.
	Shelby Tube Sampler (3.0" OD)

Unless otherwise noted, drive samples advanced with 140 lb. Hammer with 30 in. drop.

Project No. 8M087.155

LOG OF BOREHOLE NO. DH99-1

Sheet 3 of 8

CLIENT

Montana Dept. of Natural Resources and Conservation

ARCHITECT/ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

TYPE

SAMPLES

BLOWS PER 6"

NUMBER

IN. RECOVERED
IN. DRIVENPOCKET PENE-
TROMETER, TSF

TESTS

N VALUE
BLOWS/FOOT
□PL WC LL
10 20 30 40ADDITIONAL
DATA/
REMARKS

48.0

Sandy Lean to Fat Clay with Gravel (CL-CH);
stiff to hard, yellow brown to brown

5288.9

Poor Recovery due to Gravel Piece

Continued Next Page

HKM
EngineeringHKM Engineering Inc.
222 North 32nd St.
Billings, MT 59101
Telephone: (406) 656-6399
Fax: (406) 656-6398

STARTED	10/22/99	FINISHED	10/24/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

ARCHITECT/ENGINEER
HKM Engineering Inc.

PROJECT **Bair Dam**

[illegible]

HKM
Engineering

HKM Engineering Inc.
222 North 32nd St.
Billings, MT 59101
Telephone: (406) 656-6399
Fax: (406) 656-6398

STARTED	10/22/99	FINISHED	10/24/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

CLIENT

Montana Dept. of Natural Resources and Conservation

ARCHITECT/ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

to compact, brown to brownish red

GRAPHIC LOG

DEPTH (FT.)

TYPE

SAMPLES

BLOWS PER 6"

NUMBER

IN. RECOVERED
IN. DRIVENPOCKET PENE-
TROMETER, TSF

TESTS

N VALUE
BLOWS/FOOT

□

PL WC LL

10 20 30 40

ADDITIONAL
DATA/
REMARKSSample:SS-16
M.C.=12.4%
USCS=GC
Gravel=49%
Sand=29%
Fines=22%
LL=62 PI=45Sample:SS-17
M.C.=17.8%Sample:SS-18
M.C.=17.7%Sample:SS-19
M.C.=18%

Continued Next Page

HKM
EngineeringHKM Engineering Inc.
222 North 32nd St.
Billings, MT 59101
Telephone: (406) 656-6399
Fax: (406) 656-6398

STARTED	10/22/99	FINISHED	10/24/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

CLIENT

Montana Dept of Natural Resources and Conservation

ARCHITECT/ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

105.0

5231.9

105.2

5231.7

Metamorphosed Shale; olive, massive, fresh,
very strong, laminated

Lithographic Limestone/Quartzite; gray, massive
except for fractures, slightly weathered, strong,
closely fractured, fracture staining/infiltrating of
white/olive calcite, some fractures healed with
calcite, limestone fragments 1/8 to 1/16"
adjacent to healed fractures of white calcite,
white to olive carbonate laminations/bands 1/8
to 2" at 15 to 20 degrees from horizontal
observed from 108.42 to 111.42', very slight
HCL reaction on some fresh fractured surfaces
from hammer breaks

105

2

3/3.2

10

F,WS

II

17.1

110

3

5/5

38

F,WS

I,II

17.1

94.10

170.2

Run Number:3
M.C.=0.3%

115

4

5/5

50

F,WS

I,II

17.2

56.78

159.8

Run Number:4
M.C.=0.4%

117.0

5219.9

Metamorphosed Shale; gray to dark gray,
siliceous, extremely strong to very strong,
massive, highly fractured olive to light olive CO3
cement on structures and healed fractures,
CO3 (white)

120

Continued Next Page

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DRILLER	BH	ASS'T DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-1

Sheet 8 of 8

CLIENT
Montana Dept of Natural Resources and ConservationARCHITECT/ENGINEER
HKM Engineering Inc.SITE
Bair Reservoir, MontanaPROJECT
Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

123.4

5213.5

Metamorphosed/Siliceous Shale; gray to dark gray, massive, fresh, very strong, dry, highly fractured, carbonate (calcite) olive green plus iron staining (red brown) showing on fracture planes as above

125

128.4

5208.5

Bottom of Hole at 128.42 ft.

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DRILL CO.	RB&G Eng.	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
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Project No. 8M087.155

WELL COMPLETION LOG NO. DH99-01

Sheet 1 of 1

CLIENT
Montana Dept of Natural Resources and ConservationENGINEER
HKM Engineering Inc.SITE
Bair Reservoir, MontanaPROJECT
Bair Dam

Surface Elev.: 5336.9 ft. Datum: MSL

0.5 Steel Protective Cover (0' - .5') 5336.4
Bentonite Hole Plug (.5' - 48.67')48.7 5288.3
CSSI 10x20 Silica Sand Filter Pack (48.67' - 77.0')77.0 5259.9
Bentonite Hole Plug (77' - 109.5')109.5 5227.4
CSSI 10x20 Silica Sand Filter Pack (109.5' - 115.0')
115.0 5221.9
Bentonite Hole Plug (115' - 128.4')

128.4 5208.5

DEPTH (FT.)

WELL
CONSTRUCTION
Stand Pipe
CoverOpen System Piezometer
(99-1a)Observation Well
(99-1b)1" PVC Pipe
Typical1" PVC Pipe
Typical1" Slotted
(0.020") PVC
(50.0'-75.0')1" Slotted
(0.020") PVC
(111.6'-113.5')**HKM**
EngineeringHKM Engineering Inc.
222 North 32nd St.
Billings, MT 59101
Telephone: (406) 656-6399
Fax: (406) 656-6398

STARTED	10/23/99	FINISHED	10/24/99
DRILL CO	RB&G Eng	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED	JTS

CLIENT
Montana Dept of Natural Resources and Conservation

ARCHITECT/ENGINEER
HKM Engineering Inc.

SITE
Bair Reservoir, Montana

PROJECT
Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

45.5 5255.8

46.4 5254.9
Meta Quartzite (Siliceous) Shale; dark maroon, strong, highly fractured, calcite, olive to dark brown carbonate cement on fracture planes

47.6 5253.7

49.6 5251.7
Very highly fractured blue green calcareous cement on open fractures, intermittent bands of crystalline olive to blue green limestone

53.3 5248.1

58.3 5243.1
Less open fractures, numerous healed fractures with blue green to olive calcareous cement, banding of olive green crystalline appearing limestone as above throughout, light gray to light greeny gray 49.5-50.2', maroon to lavender 50.2-51.5', gray to light maroon/lavender 51.5-53.25', less fractured/broken rock

59.3 5242.1

Meta Quartzite Shale (as above)

Meta Quartzite Shale (as above); mottled

Continued Next Page

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STARTED	11/2/99	FINISHED	11/3/99
DRILL CO. RB&G Eng.		DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-2

Sheet 5 of 5

CLIENT Montana Dept of Natural Resources and Conservation	ARCHITECT/ENGINEER HKM Engineering Inc.
SITE Bair Reservoir, Montana	PROJECT Bair Dam

(continued)

gray, olive, red brown to dark red brown, very strong HCL reaction 59.25-63.25

63.3

5238.1

Meta Quartzite Shale; strong, fractured, healed fractures as above, cement not as apparent as uphole, cement on fractures dark red calcite

67.0

5234.3

Bottom of Hole at 67 ft.

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

7

4/4

10

F,WS

III,IV

8.0

65

8

1.5/3.8

40

F,WS

III,IV

8.0

55.47

166.3

Run Number:8
M.C.=0.4%**HKM**
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Fax: (406) 656-6398

STARTED	11/2/99	FINISHED	11/3/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

WELL COMPLETION LOG NO. DH99-02

Sheet 1 of 1

CLIENT
Montana Dept of Natural Resources and ConservationENGINEER
HKM Engineering Inc.SITE
Bair Reservoir, MontanaPROJECT
Bair Dam

Surface Elev.: 5301.3 ft. Datum: MSL

3.0 Steel Protective Cover (0' - .5') 5298.3

Bentonite Hole Plug (.5' - 48.67')

20.0 5281.3

CSSI 10x20 Silica Sand Filter Pack (48.67' - 77.0')

0.0 5261.3

Bentonite Hole Plug (77' - 109.5')

55.0 5246.3

CSSI 10x20 Silica Sand Filter Pack (109.5' - 115')

60.0 5241.3

Bentonite Hole Plug (115' - 128.4')

67.0 5234.3

DEPTH (FT.)

WELL
CONSTRUCTION
Stand Pipe
CoverOpen System Piezometer
(99-2a)Observation Well
(99-2b)1" PVC Pipe
Typical1" PVC Pipe
Typical1" Slotted
(0.020") PVC
(56.5'-58.5')1" Slotted
(0.020") PVC
(25.0'-40.0')**HKM**
EngineeringHKM Engineering Inc.
222 North 32nd St.
Billings, MT 59101
Telephone: (406) 656-6399
Fax: (406) 656-6398

STARTED	11/2/99	FINISHED	11/3/99
DRILL CO.	RB&G Eng	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED	JTS

CLIENT
Montana Dept. of Natural Resources and Conservation

ARCHITECT/ENGINEER
HKM Engineering Inc.

SITE **Bair Reservoir, Montana**

PROJECT **Bair Dam**

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Continued Next Page

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STARTED	10/20/99	FINISHED	10/21/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-5
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-3

Sheet 3 of 4

CLIENT Montana Dept of Natural Resources and Conservation	ARCHITECT/ENGINEER HKM Engineering Inc.
SITE Bair Reservoir, Montana	PROJECT Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

35.0

5232.4

Metamorphosed Shale; dark gray (black-wet, maroon-dry), laminated, iron/illmonite staining on fracture planes, slight HCL reaction on staining to moderate HCL reaction on white calcite

38.5

5228.9

Same as above, yellow staining showing on fracture planes

Continued Next Page

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STARTED	10/20/99	FINISHED	10/21/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-3

Sheet 4 of 4

CLIENT

Montana Dept of Natural Resources and Conservation

ARCHITECT/ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

41.2

5226.2

Strong HCL reaction 41.2-41.5', calcite
intergranular with green to yellow green shale

43.5

5223.9

As above, layered green limey shale interlayered
with dark green to black/maroon when dry,
46.7-47.5 strong HCL reaction, highly fractured
43.3-47.5

47.5

5219.9

Dark gray to black Metamorphosed Shale; very
strong

52.5

5214.9

Bottom of Hole at 52.5 ft.

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STARTED 10/20/99 FINISHED 10/21/99

DRILL CO. RB&G Eng. DRILL RIG CME-5

DRILLER BH ASST DRILLER

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Project No. 8M087.155

WELL COMPLETION LOG NO. DH99-03

Sheet 1 of 1

CLIENT

Montana Dept of Natural Resources and Conservation

ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

Surface Elev.: 5267.4 ft. Datum: MSL

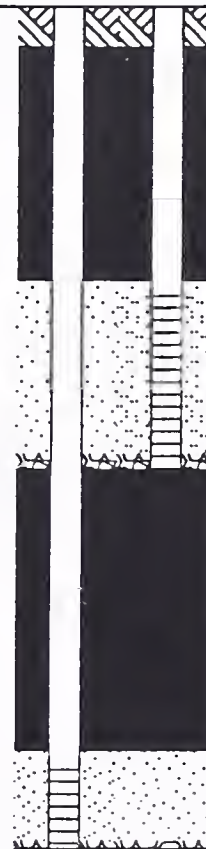
DEPTH (FT.)

WELL
CONSTRUCTION
Stand Pipe
CoverOpen System Piezometer
(99-3a)Observation Well
(99-3b)

2.5 Protective Steel Box and Cement Seal (0' - 2.5') 5264.9

Bentonite Hole Plug (2.5' - 18')

18.0 CSSI 10x20 Silica Sand Filter Pack (18' - 27.8') 5249.4

28.8 Slough (27.8'-28.8') 5238.6
Bentonite Hole Plug (28.8' - 47.5')47.5 CSSI 10x20 Silica Sand Filter Pack (47.5' - 52.5') 5219.9
52.5 5214.91" PVC Pipe
Typical1" PVC Pipe
Typical1" Slotted
(0.020") PVC
(18'-28.8')1" Slotted
(0.020") PVC
(47.5'-52.5')**HKM**
EngineeringHKM Engineering Inc.
222 North 32nd St.
Billings, MT 59101
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Fax: (406) 656-6398

STARTED	10/20/99	FINISHED	10/21/99
DRILL CO.	RB&G Eng	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED	JTS

ARCHITECT/ENGINEER

HKM Engineering Inc.

PROJECT

Bair Dam

		GRAPHIC LOG	DEPTH (FT.)	SAMPLES			TESTS				ADDITIONAL DATA/REMARKS	
				TYPE	BLOWS PER 6"	NUMBER	IN. RECOVERED IN. DRIVEN	POCKET PENE- TROMETER, TSF	N VALUE BLOWS/FOOT □			
									PL	WC		LL
Surface Elev.: 5323.5 ft. Datum: MSL												
Silty Gravel with Sand (GM); loose, dry, light gray, coarser and denser with depth				3	SS-1	10/18 56%		□				
				3								
				4								

Continued Next Page

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DRILL CO. RB&G Eng.		DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-4

Sheet 2 of 4

CLIENT

Montana Dept of Natural Resources and Conservation

ARCHITECT/ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

Surface Elev.: 5323.5 ft.

Datum: MSL

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

11.5

5312.0

Meta Quartzite Shale; maroon to deep lavender, moderately strong to strong, highly fractured, calcite and calcareous olive cement on open fractures, fractures healed with calcite cement, some fractures show red brown iron staining

14.2

5309.3

Meta Quartzite (Siliceous) Shale; as above, less infilling of fractures with cement, most fractures appear to be induced by drilling, high density of healed fractures (calcite cement)

16.7

5306.8

Meta Quartzite Shale; as above, highly fractured olive calcite showing on fracture planes

18.2

5305.3

as above

19.2

5304.3

Meta Quartzite Shale; maroon to dark gray,

Continued Next Page

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STARTED 10/29/99 FINISHED 11/2/99

DRILL CO. RB&G Eng. DRILL RIG CME-5

DRILLER BH ASS'T DRILLER

LOGGED BY JM APPROVED BY JTS

CORING 5/17 CORELOGS GPJ MSE HKM GDT 7/18/00

CLIENT

Montana Dept of Natural Resources and Conservation

ARCHITECT/ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

		GRAPHIC LOG	DEPTH (FT.)	Core Run (#)	Recovery	R.Q.D. %	Weathering Index	Strength Index	Permeability (ft/yr)	Point Load Index	Unit Weight (pcf)	ADDITIONAL DATA/REMARKS
moderately strong to strong, highly fractured, numerous healed fractures, all fractures have calcite carbonate deposits, core breaks along two planes with single moderate blow of hammer				5	5/5	33	F,WS	III,IV	1876			
24.2	5299.3											
Meta Quartzite Shale; olive gray to dark gray			25	6	4/4	9	WS	III	1006			
28.2	5295.3			7	1/1	0	WS	III	1006			
as above, highly fractured												
29.2	5294.3			8	1.4/1.4	0	WS	III	1006			
as above, x-bedding				9	1/1	0	WS	III	1006			
30.6	5292.9		30									
as above				10	2.3/2.5	14	WS	II,III	1006			
Water level during drilling				11	1.3/1.3	45	WS	III	134			
			35	12	1.8/1.8	67	WS	III	134	48.87	163.9	Run Number:12 M.C.=0.5%
				13	0/0.2							
				14	0.2/0.4	0			134			
				15	1.2/1.4	0	WS	III	134			
37.8	5285.7			16	1.6/1.8	0	WS,WM	III	134			
Meta Quartzite Shale; as above, highly fractured, calcite on fractures, olive gray												
39.2	5284.3		40									
as above, higher fracture density												

Continued Next Page

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Engineering

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DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-4

Sheet 4 of 4

CLIENT

Montana Dept of Natural Resources and Conservation

ARCHITECT/ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

40.9 5282.6

as above, olive to dark gray

42.2 5281.3

as above, dark gray, abundant rust-colored
calcite on fractures

44.2 5279.3

45.0 5278.5

46.1 5277.4

Meta Quartzite Shale; abundant planar fractures
filled with rust colored calcite, dark gray to olive
gray with bands of light gray to green alteration,
some chlorite

49.3 5274.2

Shale as above with thicker, lighter bands

50.4 5273.1

51.0 5272.5

Meta Quartzite Shale; as above, brownish-gray,
highly fractured

Bottom of Hole at 51 ft.

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STARTED 10/29/99 FINISHED 11/2/99

DRILL CO. RB&G Eng. DRILL RIG CME-5

DRILLER BH ASST DRILLER

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Project No. 8M087.155

WELL COMPLETION LOG NO. DH99-04

Sheet 1 of 1

CLIENT

Montana Dept of Natural Resources and Conservation

ENGINEER

HKM Engineering Inc.

SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

Surface Elev.: 5323.5 ft. Datum: MSL

3.0 Protective Steel Box and Cement Seal (0' - 3') 5320.5

Bentonite Hole Plug (3' - 34')

34.0 5289.5

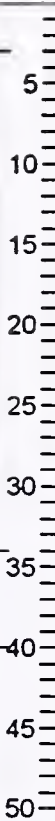
CSSI 10x20 Silica Sand Filter Pack (34' - 40')

40.0 5283.5

Bentonite Hole Plug

51.0 5272.5

DEPTH (FT.)

WELL
CONSTRUCTION
Stand Pipe
CoverObservation Well
(99-4)1" PVC Pipe
Typical →1" Slotted
(0.020") PVC
(34.5'-36.5') →**HKM**
EngineeringHKM Engineering Inc.
222 North 32nd St.
Billings, MT 59101
Telephone: (406) 656-6399
Fax: (406) 656-6398



STARTED	10/29/99	FINISHED	11/2/99
DRILL CO.	RB&G Eng	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED	JTS

Project No. 8M087.155

LOG OF BOREHOLE NO. DH99-5

Sheet 1 of 6

CLIENT
Montana Dept. of Natural Resources and ConservationARCHITECT/ENGINEER
HKM Engineering Inc.SITE
Bair Reservoir, MontanaPROJECT
Bair Dam

Surface Elev.: 5335.8 ft. Datum: MSL		GRAPHIC LOG	DEPTH (FT.)	SAMPLES				TESTS				ADDITIONAL DATA/REMARKS		
				TYPE	BLOWS PER 6"	NUMBER	IN. RECOVERED IN. DRIVEN	POCKET PENE-TROMETER, TSF	N VALUE BLOWS/FOOT					
									PL	WC	LL			
1.5	5334.3		8 13 13	SS-1	10/18 56%									
Clayey Sand with Gravel (SC) to Sandy Lean Clay (CL); compact/stiff to very stiff, slightly moist, yellow brown to brown, scattered limestone and shale 2" plus in size, drilling denser and tighter at 9', drilling very hard at 19' (impervious fill)			5	4 7 10	SS-2	14/18 78%	3.5						Sample:SS-2 M.C.=10.1%	
			10	7 12 11	SS-3	16/18 89%	4.0 4.25							Sample:SS-3 M.C.=12.3% USCS=SC Gravel=19% Sand=38% Fines=43% LL=36 PI=21
			15	5 9 12	SS-4	16/18 89%	3.25 >4.5							Sample:SS-4 M.C.=13.6%
20.0	5315.8		20											

Continued Next Page

Continued Next Page

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STARTED	10/25/99	FINISHED	10/26/99
DRILL CO. RB&G Eng.		DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

ARCHITECT/ENGINEER
HKM Engineering Inc.

PROJECT **Bair Dam**

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Continued Next Page

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STARTED	10/25/99	FINISHED	10/26/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-5
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

STARTED	10/25/99	FINISHED	10/26/99
DRILL CO.	RB&G Eng.	DRILL RIG	CME-5
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-5

Sheet 5 of 6

CLIENT
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HKM Engineering Inc.SITE
Bair Reservoir, MontanaPROJECT
Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

Water level during drilling

▽

68.9

5266.9

Shale; dark maroon to gray, metamorphosed, highly fractured, calcite, olive green NO₃ and CO₃ deposits on fracture planes

70

1

2.7/2.7

0

F,WS

II

2

0.3/3

0

WS

3

0.5/7

0

WS

II

4

0.6/6

0

F,WS

II

73.2

5262.6

Quartzite Calcareous Shale; deep lavender, highly fractured, moderately strong, grading to white dolomitic shale/limestone at 74.3', has appearance of marble, lavender and bluish green banding at approximately 45 degrees from vertical throughout, all of RQD is in white "marble" at 74.8-78.17, weak HCL reaction on hammer broken core and shavings

75

5

3.9/4.9

27

III,IV

441

77.1

5258.7

Metamorphosed Quartzitic Limestone (marble?); very light gray, very fine grained, strong to moderately strong, thin laminations of layered quartzite, dark lavender quartzitic appearing metamorphosed limestone at 79.92'

80

Continued Next Page

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DRILL CO.	RB&G Eng.	DRILL RIG	CME-55
DRILLER	BH	ASST DRILLER	
LOGGED BY	JM	APPROVED BY	JTS

Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-5

Sheet 6 of 6

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Bair Dam

(continued)	GRAPHIC LOG	DEPTH (FT.)	Core Run (#)	Recovery	R.Q.D. %	Weathering Index	Strength Index	Permeability (ft/yr)	Point Load Index	Unit Weight (pcf)	ADDITIONAL DATA/REMARKS
81.7	5254.1		6	4/4.7	28	F	III,IV	441			Run Number:7 M.C.=0.1%
As above, dark maroon/gray shale, cementing of fractures, calcite and light olive green calcareous, change in core color to olive at 87.3'		85	7	4.7/4.7	47	F	III,IV	125	122.15	181.8	
86.4	5249.4										Run Number:8 M.C.=0.1%
Metamorphosed Quartzitic Limestone (marble?); white to light gray with intermittent banding of light olive and lavender/maroon		90	8	4.9/5.1	41	F	III,IV	125	149.40	171.6	
91.5	5244.3										
92.6	5243.2										
Appearing Shale, lavender to dark maroon, dark gray with laminations of blue green to light olive dolomitic limestone, fresh, fractured, fracture planes calcareous olive green, white and red brown deposited cementing											
Bottom of Hole at 92.6 ft.											

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WELL COMPLETION LOG NO. DH99-05

Sheet 1 of 1

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Bair Dam

WELL
CONSTRUCTION
Stand Pipe
Cover

Surface Elev.: 5335.8 ft. Datum: MSL

2.0 Protective Steel Box and Cement Seal
(+2.51 - 2')

5333.8

Bentonite Hole Plug (2' - 45')

DEPTH (FT.)

5

10

15

20

25

30

35

40

45

50

55

60

65

70

75

80

85

90

45.0

5290.8

CSSI 10x20 Silica Sand Filter Pack (45' - 57.5')

57.5

5278.3

Bentonite Hole Plug (57.5' - 77')

77.0

5258.8

CSSI 10x20 Silica Sand Filter Pack (77' - 82')

82.0

5253.8

Bentonite Hole Plug (82' - 92.6')

92.6

5243.2

Open System Piezometer
(99-5a)Observation Well
(99-5b)1" PVC Pipe
Typical1" PVC Pipe
Typical1" Slotted
(0.020") PVC
(47.5'-57.5')1" Slotted
(0.020") PVC
(80'-81.5')**HKM**
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PROJECT **Bair Dam**

Surface Elev.: 5301.6 ft. Datum: MSL	GRAPHIC LOG	DEPTH (FT.)	SAMPLES				TESTS				ADDITIONAL DATA/REMARKS
			TYPE	BLOWS PER 6"	NUMBER	IN. RECOVERED IN. DRIVEN	POCKET PENE-TROMETER, TSF	N VALUE BLOWS/FOOT			
								PL	WC	LL	
Silty Gravel with Sand (GM); compact, slightly moist, gray, tabular and angular, boulder and cobble size riprap (rock shell)		7 8 11		SS-1	8/18 44%						
Gravelly Lean to Fat Clay (CL-CH); firm to stiff, moist, gray to red brown, subrounded to rounded cobbles at 2-6', varies to sandy lean clay with gravel (CL); sof to stiff with depth, red brown, scattered rocks 2" plus (limestone and metashale throughout) (impervious embankment)		5 4 3 4		SS-2	12/18 67%						Sample:SS-2 M.C.=19.5%
Permeability: 13.5'-18.5', k=0 ft/yr 13.5'-23.5', k=15 ft/yr		10 3 4 6		SS-3	13/18 72%						Sample:SS-3 M.C.=24.8% USCS=CH Gravel=17% Sand=32% Fines=51% LL=63 PI=45
Extra Samples Taken in DH-6a SH-1 10'-12', 24"/24"=100% M.C.=31.3% Cohesion=640 psf Phi=18.7 degrees Dry Unit Wt=85.1 pcf		15 3 6 7		SS-4	16/18 89%	1.75 2.5					Sample:SS-4 M.C.=28.3%

Continued Next Page

STARTED	10/27/99	FINISHED	10/29/99
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Project No. 8M087.155

LOG OF BOREHOLE NO. DH99-6

Sheet 2 of 5

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Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

(continued)	GRAPHIC LOG	DEPTH (FT.)	SAMPLES				TESTS				ADDITIONAL DATA/REMARKS	
			TYPE	BLOWS PER 6"	NUMBER	IN. RECOVERED IN. DRIVEN	POCKET PENE-TROMETER, TSF	N VALUE BLOWS/FOOT				
								PL	WC	LL		

Continued Next Page

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SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

(continued)

42.0 5259.6

42.8 Metamorphosed Shale; maroon, moderately strong, fractured 5258.9

44.7 Metamorphosed Shale; same as above, maroon to 42.25', grading to light maroon (44.25-45'), olive banding, highly fractured, olive calcareous cement on fracture planes 5256.9

47.8 Metamorphosed Shale; maroon to light lavender, strong to very strong, highly fractured, iron staining on fracture planes, healed fractures 5253.9

49.3 Metamorphosed Shale; maroon to dark gray, moderately strong to strong, (quartzitic shale) 5252.3

52.7 Metamorphosed Shale; maroon, strong, highly fractured, blue green banding 0.2" thick, infilling with cement on fracture planes, blue green and red brown calcareous and calcite (quartzitic shale) 5248.9

57.7 Metamorphosed Shale - Weak Quartzite; moderately strong to strong, fresh to slightly weathered, cement on open fractures, calcite and calcareous blue green and light olive deposits 5243.9

Continued Next Page

Run Number:3
M.C.=0.2%Run Number:4
M.C.=0.2%**HKM**
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LOG OF DRILLHOLE NO. DH99-6

Sheet 5 of 5

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PROJECT

Bair Dam

(continued)

60.2 Quartzite Shale; maroon, dark lavender, moderately strong to strong, fresh cement on fracture planes, calcite, red brown iron staining, blue green calcareous, noted small intergranular calcite (quartz appearance) in all meta shale and quartzite shale

62.8

5241.4

5236.9

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

8

2.5/2.5

32

III

242

Bottom of Hole at 62.75 ft.

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LOG OF BOREHOLE NO. DH99-7

Sheet 1 of 6

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Surface Elev.: 5320.4 ft. Datum: MSL

0.5 Topsoil

5319.9

Silty Gravel with Sand (GM) to Silty Clay with Sand (CL); moderately dense, dry to slightly moist, brown to red brown, scattered tabular and angular rock of cobble and boulder size throughout

5.0

5315.4

Silty Sand (SM) grading to Clayey Sand with Gravel (SC) at 10'; compact, calcareous, slightly moist, yellowish brown

GRAPHIC LOG

DEPTH (FT.)	SAMPLES				TESTS				ADDITIONAL DATA/REMARKS			
	TYPE	BLOWS PER 6"	NUMBER	IN. RECOVERED IN. DRIVEN	POCKET PENE- TROMETER, TSF	N VALUE BLOWS/FOOT □						
						PL	WC	LL				
						10	20	30	40			
9		9	SS-1	11/18 61%								
11		11						□				
14		14										
5		5	SS-2	11/18 61%								
10		10						□				
11		11										
10		6	SS-3	11/18 61%								
8		8						□				
16		16										
15		7	SS-4	12/18 67%						Sample:SS-4 M.C.=9% USCS=GC Gravel=40% Sand=25% Fines=35% LL=25 PI=8		
8		8				●	□	—				
9		9										
20												

Sample:SS-4
M.C.=9%
USCS=GC
Gravel=40%
Sand=25%
Fines=35%
LL=25 PI=8

Continued Next Page

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Project No. 8M087.155

LOG OF DRILLHOLE NO. DH99-7

Sheet 3 of 6

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Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

36.8

5283.7

37.5

5282.9

Siliceous Shale; dark gray, laminated olive to olive brown, highly fractured, rust/red brown deposits on fracture planes, laminated olive to olive brown, strong HCL reaction (limey shale or shaley limestone), dry

Gravelly Silty Clay with Sand (CL-ML); hard, slightly moist, yellow gray, highly weathered

Continued Next Page

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Bair Dam

(continued)	shale	GRAPHIC LOG	DEPTH (FT.)	Core Run (#)	Recovery	R.Q.D. %	Weathering Index	Strength Index	Permeability (ft/yr)	Point Load Index	Unit Weight (pcf)	ADDITIONAL DATA/REMARKS
42.8												
	Siliceous Shale; dark gray, very fine grained, strong, interlayered with olive fine grained calcareous cement deposits in healed fractures (43.9-45-4'), (chert chalcedony?), no HCL reaction, gray to light gray, strong, aphanitic interlayered with bands of olive calcareous as above 45.4-47'			4	0.8/4	0	WS	III,IV				
47.0			45	5	3.8/3.8	40	F,WS	III				
48.0	Crystalline Limestone, light gray to light olive gray, fine grained, moderately strong, dry			6	0.9/0.9	0	WS,WM	III				
	Limestone; light gray to light olive gray, fine grained, strong, fresh, dry, cave of clay and shale from 36.75 to 43', driller reported clay squeezing in at 37-43', removal of core tools, reamed hole to 43' to set casing and continue coring, light olive banding as above on approximate 0.2-0.5' centers throughout run		50	7	4.7/5	77	F	III		100.17	179.6	Run Number:7 M.C.=0.2% Slake Durability=99.2%
			55	8	5.3/5	57	F	III		92.80	180.7	Run Number:8 M.C.=0.1%
60.0			60									Run Number:9 M.C.=0.2% Slake

Continued Next Page

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LOG OF DRILLHOLE NO. DH99-7

Sheet 5 of 6

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PROJECT

Bair Dam

(continued)

Siliceous Shale; very fine grained to aphanitic,
light gray to gray, strong fresh, calcite
cementation healed fractures to open fractures

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

Durability=99.5%

Run Number:10
M.C.=0.2%Run Number:11
M.C.=0.1%
Slake
Durability=99.5%Run Number:12
M.C.=0.1%Run Number:13
M.C.=0.2%

77.6

5242.8

Dolomitic Marble; gray to light gray to light olive
gray, strong to very strong, massive, medium to
coarse grained with phenocrysts of calcite,
black to dark gray limestone, fresh, dry

Continued Next Page

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LOG OF DRILLHOLE NO. DH99-7

Sheet 6 of 6

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SITE

Bair Reservoir, Montana

PROJECT

Bair Dam

(continued)

GRAPHIC LOG

DEPTH (FT.)

Core Run (#)

Recovery

R.Q.D. %

Weathering Index

Strength Index

Permeability (ft/yr)

Point Load Index

Unit Weight (pcf)

ADDITIONAL
DATA/
REMARKS

86.8

5233.6

Dolomitic Limestone/Marble; gray, strong to very strong, granular, fine grained grading to aphanitic, numerous healed fractures

89.8

5230.6

Dolomitic Marble; phenocrysts 1-2mm of calcite (white) with dark gray to black limestone in matrix, very fine grained to aphanitic texture

NOTE: Inclinator installed in hole using standard Sinco 1.9" casing. Casing set with cement and bentonite.

98.6

Bottom of Hole at 98.6 ft.

5221.8

85

16

5.1/5

75

F

II

103.72

159.1

Run Number:16
M.C.=0.3%

90

17

5.1/5

88

F

II

126.21

181.2

Run Number:17
M.C.=0.1%
Slake
Durability=99.2%

95

18

5.5/5.5

73

F

I,II

11.07

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APPENDIX E

TEST PIT LOGS

(Note: Two of the test pits (TP99-1 and TP99-2) were excavated along the southwest shore of the lake and two (TP99-3 and TP99-4) were excavated in the original borrow area used during construction of the dam south of Highway 12. See Figure 6-2 in the Bair Dam Rehabilitation Feasibility Study Report, dated October 1, 2000, for location of the test pits.)

Test Pit Logs:

Bair Dam

Montana Department of Natural Resources and Conservation

Test Pit TP-1:

Approximate Surface Elevation 5309 (ft)

- 0.0 – 3.5 ft. Sandy Gravel (GP); loose to compact, brown, little silt, occasional cobbles, max size 12", gravels are sub-rounded.
- 3.5 – 10.0 ft. Sand and Gravel (GP); compact, grayish brown, little to some silt, gravel size particles are angular broken pieces of bedrock, material is shale like, no groundwater encountered.

Test Pit TP-2:

Approximate Surface Elevation 5306 (ft)

- 0.0 – 1.0 ft. Topsoil
- 1.0 – 4.5 ft. Gravelly Clay (CL-ML); firm, moderate brown, (fill?)
- 4.5 – 10.0 ft. Gravelly Clayey Silt (ML); firm, brown, water at 9.5 ft.

Test Pit TP-3:

Approximate Surface Elevation 5480 (ft)

- 0.0 – 5.0 ft. Silty Clay (CL); firm, weathered, brown-gray, (weathered bedrock?)
- 5.0 – 9.0 ft. Silty Clay (CL); firm/hard, reddish brown, vari-colored angular fragments (Shale) in silty clay matrix (Colluvium?)
- 9.0 – 10.0 ft. Becomes brownish gray with cobbles, 8" max size, moist

Test Pit TP-4:

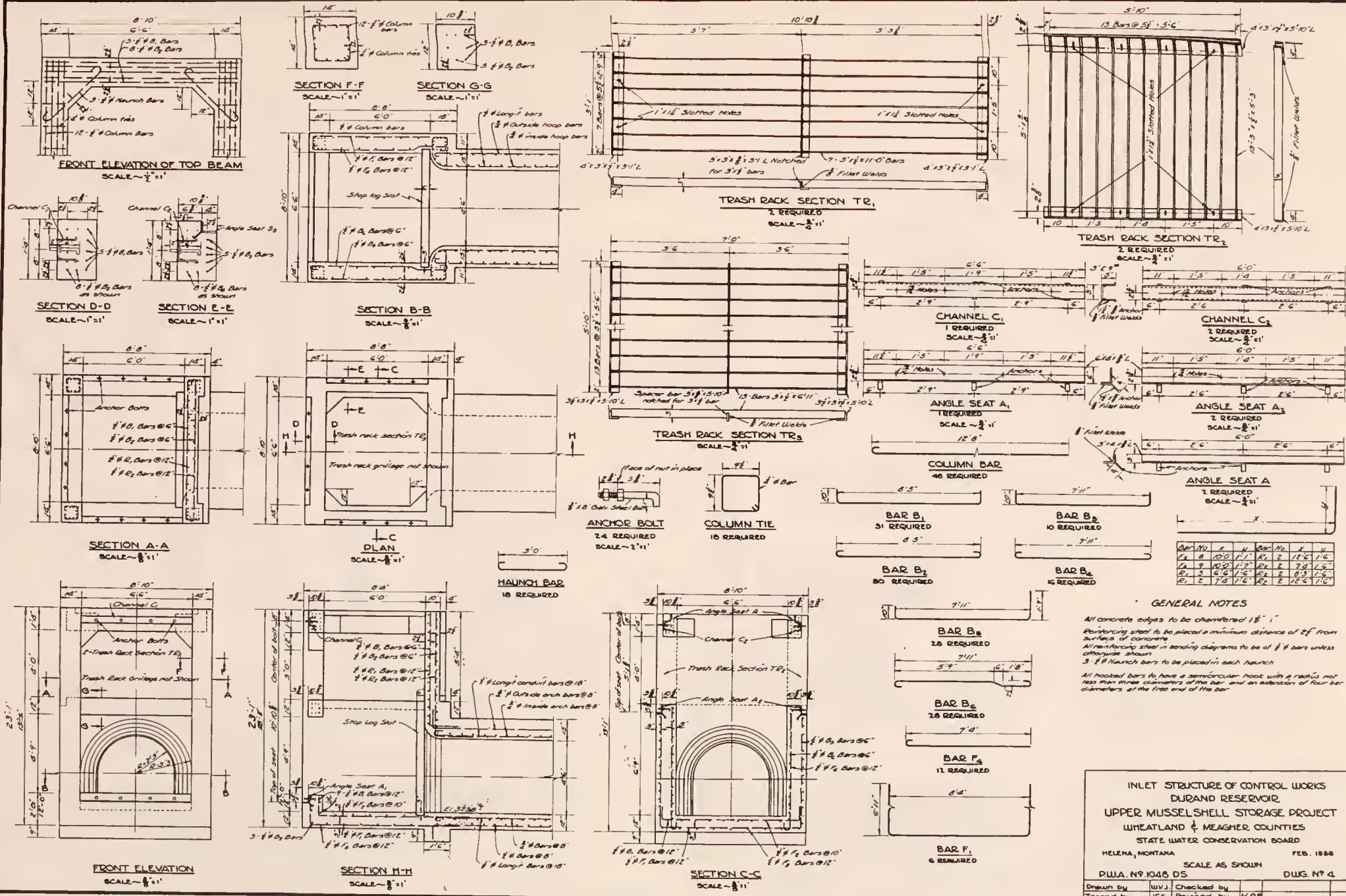
Approximate Surface Elevation 5490 (ft)

- 0.0 – 0.5 ft. Topsoil
- 0.5 – 5.0 ft. Silty Clay (CL); firm/hard, mottled red, brown/gray, occasional cobble size clast, dry to slightly moist
- 5.0 – 10.0 ft. Silty Clay (CL); firm, reddish brown, (weathered bedrock?), becoming damp

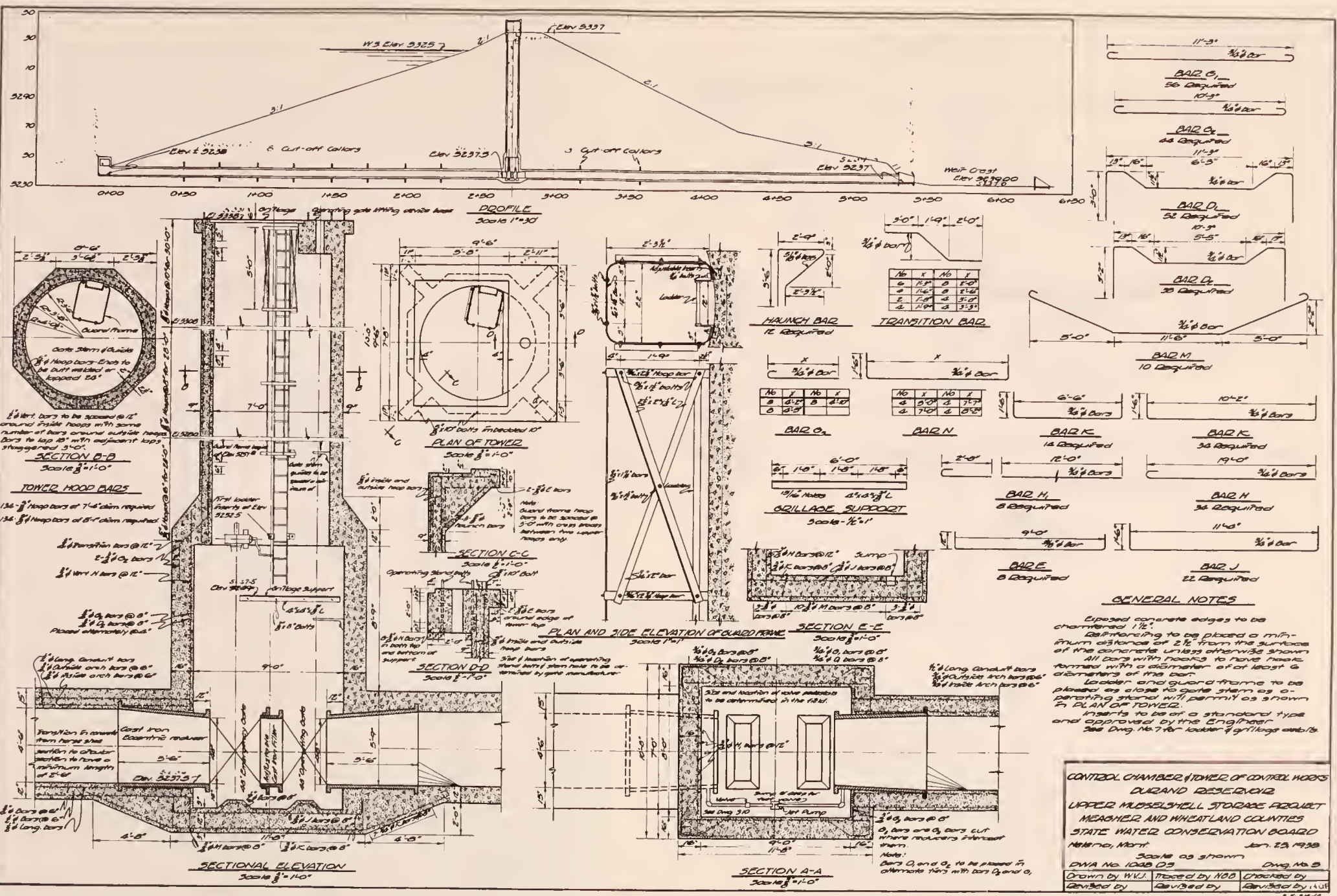
APPENDIX F

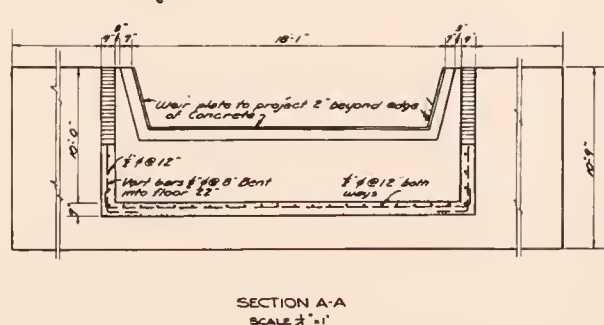
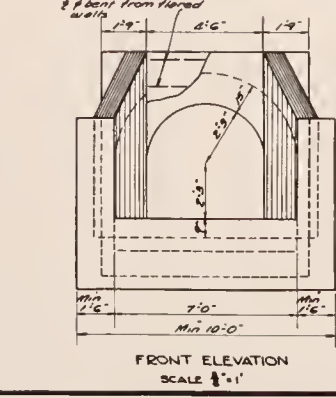
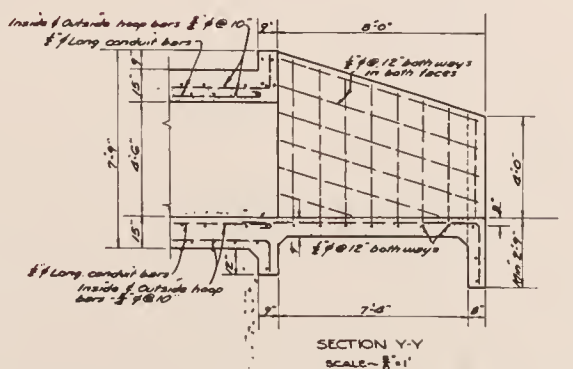
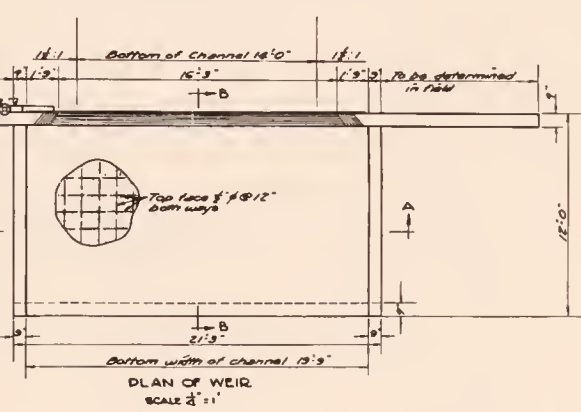
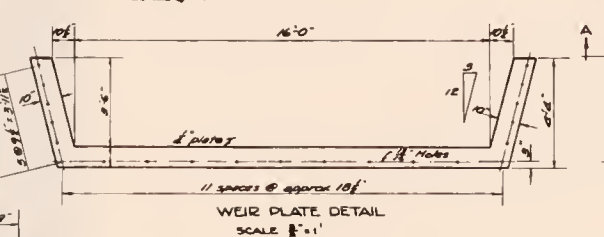
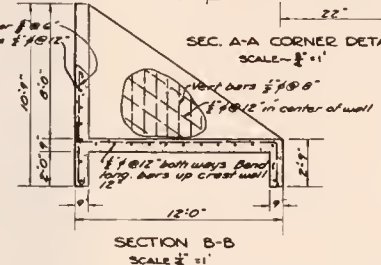
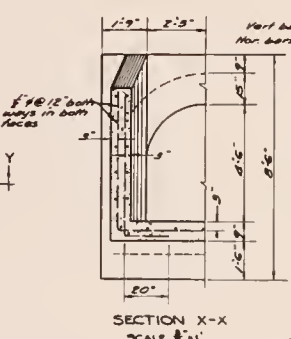
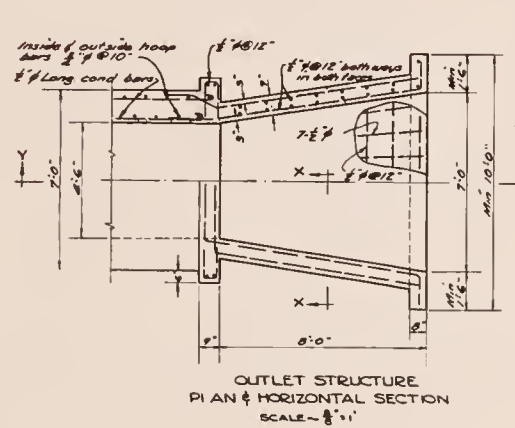
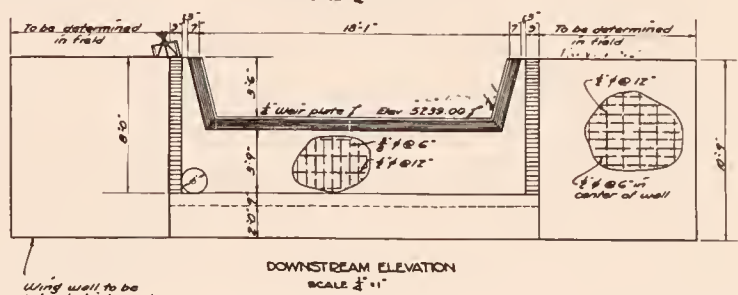
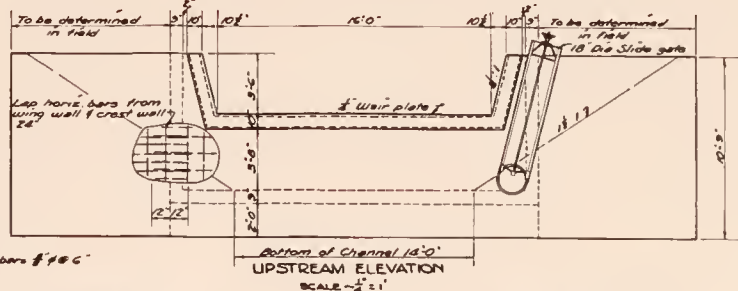
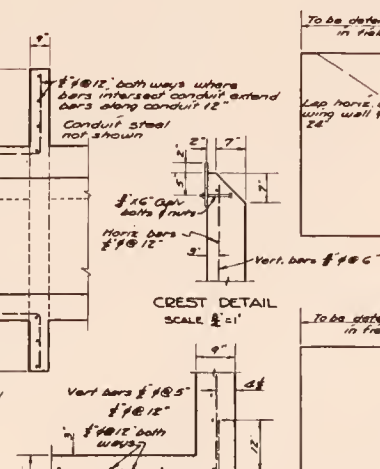
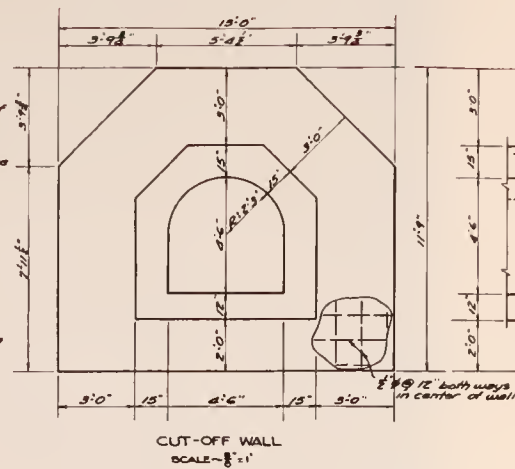
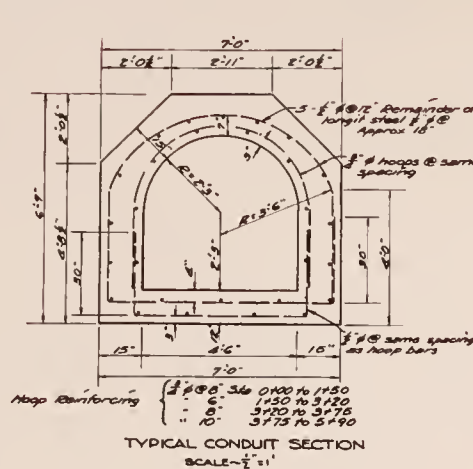
PROJECT DRAWINGS

(NOTE: These reduced project drawings are design drawings and not "As Builts". These drawing should be used for reference only. The SWPB has the full size project drawings.)



INLET STRUCTURE OF CONTROL WORKS
DURAND RESERVOIR
UPPER MUSSEL SHELL STORAGE PROJECT
WHEATLAND & MEAGHER COUNTIES
STATE WATER CONSERVATION BOARD
HELENA, MONTANA
FEB. 1988
SCALE AS SHOWN
PWLA N9.1046 DS
DWG. N9.4
Drawn by WVS Checked by JCK
Traced by JCK Revised by HOB





GENERAL NOTES

Character all exposed edges of concrete 1"
Minimum distance between face of concrete
and reinforcing steel to be 2 1/2"

CONDUIT OUTLET STRUCTURE & WEIR OF CONTROL WORKS
DURAND RESERVOIR
UPPER MUSSELSHELL STORAGE PROJECT
WHEATLAND & MEASHER COUNTIES
STATE WATER CONSERVATION BOARD
HELENA, MONTANA FEB, 1988

SCALE AS SHOWN

PULL NO. 1048 DS DRAWING NO. 6

Drawn by	BYW	Checked by			
Traced by	JCK	Revised by	H/L		

